Executive Summary

Plan

The Rio Blanco County Pre-Disaster Natural Hazards Strategic Mitigation Program and Plan provides information on natural hazards and options for mitigating potential hazards events in the county. This includes a list of activities that Rio Blanco County can implement to reduce risk and prevent loss from future natural hazard events. These events include all the prevalent natural hazards presented by flood, avalanche, wildfire, and geologic instability.

How is the Plan Organized?

The Mitigation Plan contains a list of priorities that was derived from a list of potential projects. . The process for determining how these priorities were determined is described in this plan. Additionally the plan describes how the priorities were determined based on the natural hazards that exist in the county as well as the process for analyzing the hazard situation to reveal where the community may be at risk from natural hazards.

Who Participated in Developing the Plan?

The Rio Blanco County Pre-Disaster Natural Hazards Strategic Mitigation Program and Plan is the result of a collaborative effort between Rio Blanco County citizens, public agencies, non-profit organizations, the private sector, and federal and state organizations. Public participation played a key role in development of goals and action items. The plan was developed using information from stakeholders across the county at multiple public meetings. The Local Emergency Planning Council, the Emergency Medical Services Council and the attendant sub-committees guided the process of plan development.

What is the Plan Mission?

The mission behind the Rio Blanco County Pre-Disaster Natural Hazards Strategic Mitigation Program and Plan is to promote sound public policy to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards that can be mitigated and controlled through reasonable and cost effective methods that balance ecological, social, cultural, and resource objectives of the various stakeholders. This can be achieved with public support for implementing risk reduction, loss-prevention, and hazard mitigation activities such that the community moves toward a more sustainable future.

What are the Plan Goals?

The goal of the plan is to describe the types of hazards that face the community within Rio Blanco County and offer alternatives to just having these disastrous events occur. Prevention is better than the cost of cleanup particularly when it involves reasonably foreseeable events. The goals of this plan are to provide recommendations that can:

- **Protect Life and Property**
  - Implement activities that assist in protecting lives and environment by making homes, businesses, infrastructure, critical facilities, and other property more resistant to losses from natural hazards.
  - Reduce losses and repetitive damages for chronic hazard events while promoting insurance coverage for catastrophic hazards.

- Improve hazard assessment information to make recommendations for discouraging new development and encouraging preventative measures for existing development in areas vulnerable to natural hazards.

- **Public Awareness**
  - Develop and implement education and outreach programs to increase public awareness of the risks associated with natural hazards.
  - Provide information on tools, partnership opportunities, and funding resources to assist in implementing mitigation activities.
- **Natural Systems**
  - Balance watershed planning, natural resource management, and land use planning with natural hazard mitigation to protect life, property, and the environment.
  - Preserve, rehabilitate, and enhance natural systems to serve natural hazard mitigation functions.
- **Partnerships and Implementation**
  - Strengthen communication and coordinate participation among and within public agencies, citizens, non-profit organizations, business, and industry to gain a vested interest in implementation.
  - Encourage leadership within public and private sector organizations to prioritize and implement local, county, and regional hazard mitigation activities.
- **Emergency Services**
  - Establish policy to ensure mitigation projects for critical facilities, services, and infrastructure.
  - Strengthen emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.
  - Coordinate and integrate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures.

How are the Mitigation Action Items Organized?

The mitigation action items are a listing of projects that could be implemented to prevent or reduce the impact from presented by natural hazards. As part of RBC's commitment to promoting overall health, safety and welfare the Development Department will facilitate, project manage, and seek funding (where applicable) for the mitigation activities outlined by working in partnership with public agencies and private parties to complete the mitigation in a consensus based manner. The mitigation action items have been developed from differing types of assessment of hazards and problems in the areas of highest concern that have been identified. A list of potential mitigation activities was presented to the working committees. From this list the committees ranked, through a voting process, their preferences of activities for mitigation. Each project has the following information developed for it and these are the criteria the committees considered in ranking projects:

Name, Number, and Hazards Addressed: The name, RBC mitigation activity number (RBCM#) and types of hazards addressed such as wildfire, flood, erosion, debris flow, etc.
Type: The generic classification for the type(s) of activity such as constructing (Includes activity such as fuel reduction), studying, engineering, planning, facilitating, financing
Purpose: The generic reason for the type of activity. A partial list includes creating, information/maps, designing project features, analyzing situations/NEPA, regulatory compliance, consensus building, defining options and approaches, understanding dynamics and options, seeking funding, building and/or accomplishing mitigation features and activities.

Scale: Extent of area and or complexity for the activity such as broad (1/4 of RBC and/or ecologically/very complex), standard (confined to a given area/sub-basin and/or moderately complex), narrow (Site specific and/or complexity is resolution of engineering problem)
Span: Defining the time scale for the activity-short-term, mid-term, long-term.
Description: Narrative on the character of the problem.
Resources: Provides a basic outline of stakeholders.
Cost/Benefit: Outlines resources at risk and cost if situation is not addressed.
Mitigation: Project expectations and/or assumptions about possible mitigation approaches.

Matrix of Mitigation Projects / Action Plan

RBC Mitigation Project Number	Name of the Project	Hazard	Priority Number	Level of Urgency	BCA
RBCM#-001	Flash Flooding and Highly Erosive Lands Dynamics Study for Western RBC.	Flash Flood, Debris flows, Erosion/Deposition, Collapsing Soils	**10**	**2**	**1+**
RBCM#-002	Upper Kenney Floodplain Shifting Analysis.	Erosion/Deposition	**12**	**2**	**1+**
RBCM#-003	Arresting Flash flood and Erosion through Riparian and Creek Restoration Projects.	Flash Flood, Debris flows, Erosion/Deposition, Collapsing Soils	**2**	**3**	**3+**
RBCM#-004	RBC Community Based Consensus and Solutions for Watershed Sustainability.	All Hazards except Avalanche	**5**	**2**	**1+**
RBCM#-005	Updating Information Bases for Decision-makers.	Flash Flood, Spring Flows	**14**	**2**	**1+**
RBCM#-006	Understanding the Dynamic of Kenney reservoir	Spring Flows, Ice Jams	**13**	**2**	**1+**
RBCM#-007	Responding to Ice jam threats.	Ice Jams, Extreme Cold	**15**	**3**	**1**
RBCM#-008	Mitigation of Ice Jams Around Meeker	Ice jams, Extreme Cold	**16**	**1**	**1**
RBCM#009	Water Passage Structures on CR-5	Flash Flood, Debris flows, Erosion/Deposition	**3**	**2**	**2+**
RBCM#010	Repairing Stability in Highly Erosive Creeks	Erosion/Deposition	**11**	**2**	**1+**
RBCM# 011	Eastern Rio Blanco County Electrical Infrastructure Wildland Fire Mitigation Project	Wildfire	**1**	**3**	**10+**
RBCM# 012	Preplanning Avalanche Response	Avalanche	**6**	**2**	**1+**
RBCM# 013	North Meeker Trail Wildfire Mitigation Project	Wildfire, erosion/deposition	**4**	**2**	**2+**
RBCM#014	Extreme Cold and Snow Prepardedness	Extreme Cold and Snow	**8**	**2**	**1**
RBCM#015	Drought Preparedness	Drought	**7**	**2**	**2+**
RBCM#016	Wolf Creek Reservoir,	Drought, erosion/deposition	**9**	**1**	**2+**

BCA estimates need to be further refined (greater than 1 indicates a benefit over a cost)
Level of Urgency: 3 = ASAP, 2 = within several years, 1 = need to be completed yet has long-term horizon.

How Will the Plan be Implemented, Monitored, and Evaluated?

The Plan Sustainability Section of this document details the formal process that has been used to ensure that the Rio Blanco County Natural Hazards Mitigation Plan remains an active and relevant document. The plan sustainability process includes a schedule for monitoring and evaluating the Plan annually and producing a plan revision at least every five years. This section describes how the county will integrate public participation throughout the plan maintenance process. Finally, this section includes an explanation of how Rio Blanco County government intends to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms such as the County Comprehensive Land Use Plan, Land Use Resolution, Capital Improvement Plans, and Building Codes.

Plan Adoption

The Board of County Commissioners (BOCC) will be responsible for adopting the Rio Blanco County Natural Hazards Mitigation Plan. This governing body has the authority to promote sound public policy regarding natural hazards.

Coordinating Body

The Rio Blanco County Emergency Management Council facilitated by the County Emergency Manager is the oversight board for coordinating this plan. The Development Department is responsible for updating, facilitating, undertaking the formal review processes, implementing mitigation activities of this plan. The Development Department solicits participation of representatives from various agencies and private stakeholders to work on hazard issues and refers consensus items to the County Emergency Planning Council that recommends them to the BOCC. Project Management is facilitated by the Development Department.

Convener

The BOCC adopts the Rio Blanco County Natural Hazard Mitigation Plan for the County and the Development Department implements the program. The County Emergency Planning Council and its subcommittees for hazard mitigation provide oversight and recommendation for plan implementation. The Director of the Development Department serves as ***convener*** to facilitate meetings and maintain the plan. Plan implementation and evaluation is a shared responsibility among all the various stakeholders.

Implementation through Existing Programs

Rio Blanco County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Program, Capital Improvement Plans, and Building Codes. This plan provides a series of recommendations that are closely related to the goals and objectives of these existing planning programs. Rio Blanco County will attempt to implement recommended mitigation action items through existing programs and procedures as a matter of first course and only seek additional funds when necessary. Upon adoption of the Mitigation Plan, the county will facilitate multi-jurisdictional activities to implement natural hazard mitigation goals and actions.

Economic Analysis of Mitigation Projects

The Federal Emergency Management Agency requires that projects be implemented after it has been demonstrated that mitigation shall prevent excessive costs that could result from a potential disaster. Two methods are used to determine whether this criterion has been met: benefit/cost analysis and cost-effectiveness analysis. Conducting benefit/cost analysis for a mitigation activity assists communities in determining whether a project is worth undertaking now in order to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards is necessary to provide decision makers with an understanding of the potential benefits and costs of an activity and a basis upon which to compare alternative projects.

Formal Review Process

The Rio Blanco County Natural Hazards Mitigation Plan will be updated as projects are completed and information is received. An adaptive approach will be utilized so the plan reflects what is learned as the program is implemented. A new document will be produced based on what is learned, the effectiveness of programs, and changes in land development patterns that may affect mitigation priorities. The convener will be responsible for maintaining the plan including organizing regular meetings and updating action lists.

Continued Public Involvement

Rio Blanco County is dedicated to involving the public directly in the continual review and updates of the Hazard Mitigation Plan. Copies of the plan will be available on compact disc and on the county web-site. The plan also includes the address and the phone number of the county Development Department. In addition changes to the plan, mitigation success stories will be posted on the county website. This site will also contain an email address and phone number to which people can direct their comments and concerns.

Note on the Resource List:
The organizations listed in the Resource Directory have a vested interest in natural hazards and may not have all been involved with the development of the plan.

Special Thanks & Acknowledgements Project Steering Committee:

RBC

- RBC Planning Commission, critique and direction
- Lance Stewart, Rangely Town Manager, critique and direction
- Paula Davis, Rangely Fire Protection District, critique and direction
- Joe Dugan, USGS, critique and direction
- Alvin Jones, NRCS, critique and direction
- Ann Brady and Peggy Rector, RBC Water Conservation District, critique and direction
- Denise Sheridan, Town of Meeker, critique and direction
- Mike Frary, USBLM, critique and direction
- White River Resource Area Staff, USBLM, critique and direction
- Bob Tobin, critique and direction
- Chuck Whiteman, critique and direction
- Rio Blanco County Local Emergency Planning Council
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- Jeff Devere, RBC Planner, principal author and GIS
- Todd Archer, RBC IT/GIS, Technical review and support
- Sandy Whalin and her precious that without her efforts the Development Department would not function.

Note on the Maps in the Plan

The information on the maps in this plan was derived from Rio Blanco County's GIS. Care was taken in the creation of these maps, but is provided "as is." Rio Blanco County cannot accept any responsibility for any errors, omissions or positional accuracy, and therefore, there are no warranties that accompany these products (the maps). Although information from Land Surveys may have been used in the creation of these products, in no way does this product represent or constitute a Land Survey. Users are cautioned to field verify and check out information on this product before making any decisions.

Part I

Introduction

FEMA estimates that for every dollar spent in damage prevention, two are saved in repairs. Examples of this abound as when in the early 1980s the Anheuser-Busch brewery near Northridge California invested $15 million to protect its facilities from earthquakes. As a result they received only minor damage during the 1994 quake. The estimate is that if they had faced the earthquake unprepared their losses could have exceeded $300 million. However because of their preparations operations never stopped and repair costs were minimal. Clearly, sound comprehensive mitigation programs as part of a successful overall emergency/disaster management approach that can reduce the impact of disasters and emergencies and lessen the disruption they cause in peoples lives.

Rio Blanco County Colorado is a sparsely populated rural county with a total area of 3,263 square miles bordered by other sparsely populated rural counties. The economic base is agricultural, mineral, oil and gas. A very large percentage of the land within the county is owned by the federal government (73%) and encompasses a diverse range of ecological zones and land uses. These lands have some of the highest risk indexes for probability of wildfire events, and impacts from these events, as any county within the state of Colorado (Neuenschwander et al. 2000, Despain et al. 2000). These public lands are also a large draw to those looking for outdoor activities. Hunters, hikers, snowmobilers and associated outdoor activities are common activities on these lands. Additionally, much of the public land is administered for multiple use. Meaning recreational uses coexist with oil/gas and mineral production, grazing, logging and other permissible land uses. Given the diversity of uses of the land and a low population, the county faces a unique and particular set of hazard and emergency issues.

In order to properly manage potential hazards in a timely manner, accurate information before, during, and after emergencies is critical. Information that is collected has to be utilized to have a positive effect on the emergency situation at every given step in the emergency/disaster management sequence. In many cases emergencies can be prevented. Thus the management system has to be proactive as well as a reactive when an emergency does occur. As the region changes the circumstances that lead to emergencies and disasters will shift. Rio Blanco County is faced with a variety of natural and man-made hazards, including wildfires, floods, landslides, potential dam failure, and drought. Efficient management of resources logically prescribes that before an emergency/disaster occurs the county must consider the consequences and act in a responsible manner to prevent the deleterious effects, and if a situation does occur be ready to respond. No matter how severe the problem, the local government and community (in the broadest sense including local representatives of state and federal agencies) will have to confront the situation. This means that emergency/disaster management planning is critically important to ensure that as much as possible is prevented from occurring and everyone is prepared. While accidents and disasters happen and cannot be completely controlled or anticipated, good planning and preparation will lessen the severity of events and save lives.

State Law (Colorado Disaster Emergency Act of 1992) establishes that local governments have an effective emergency/disaster management program that includes:

1) A community hazard analysis;
2) a current local Emergency/Disaster operations plan;
3) a communications system to enable you to function and to warn citizens of disaster;
4) evacuation plans and public shelters;
5) a program to inform citizens of ways they can protect themselves;
6) trained personnel to handle specialized jobs like controlling hazardous materials; and
7) a program to ensure that personnel have the necessary resources to do the job.

The implementation of a comprehensive program of mitigation is a key component in addressing concerns. Through mitigation hazard analysis will be completed and the character of potential natural hazards will be confronted. These are the steps necessary to further outline and implement a comprehensive program of emergency/disaster management necessary for the long-term success of the community. Emergency/disaster management is defined as a continuous process (program) for making decisions about how the community is going to mitigate, prepare, respond and recover from emergencies and disasters. The success of an emergency/disaster management program at any scale depends on the proper implementation of practices, procedures, and plans for lessening potential risks. This is a key reason for mitigation and understanding the nature of the character of the risks faced. Key components of a successful program should include:

<u>CHARACTERIZATION</u>: Any action carried out to characterize the nature of hazards and/or determine extent, monitor potential or identify new criteria to be considered as a risk. General measures include:

-Land Use Assessments	-Hazard/Risk Mapping	-Monitoring/Inspection
-Hazard/Risk Analysis	-Hazard Identification	-Risk Assessment

<u>MITIGATION:</u> Any action taken to eliminate or reduce the degree of risk to the community from natural and man-made hazards. Mitigation assumes that society is exposed to risks whether or not an Emergency/Disaster occurs. General measures include:

-Building Codes	-Land Use Management	-Disaster Insurance
-Safety Codes	-Public Education	-Statutes/Ordinances
-Structural Projects	-Tax Incentives/Disincentives	-Land Restoration

<u>PREPAREDNESS:</u> Any activity taken in advance of an Emergency/Disaster that facilitates the implementation of a coordinated response in the event an Emergency/Disaster occurs. General Measures include:

-Continuity of Government-	Emergency Operations Plans	-Warning Systems
-Emergency Communications	-Mutual Aid Agreements	-Tests/Exercises
-Identify Shortfalls/Capabilities	-Emergency Broadcast System	-Resource Management
-Public Information Materials	-Training	-Hazard Analysis

<u>RESPONSE:</u> Any action taken immediately before, during or directly after an emergency/disaster that is intended to save lives, minimize impact and increase the effectiveness of recovery. General measures include:

-Activate Emergency Plan	-Data Collection for Damage	-Activate EOC
-Activate Warning System	-Activate Mutual Aid/	-Alert EOC Staff
-On-Scene Control	-Search and Rescue	-Resource Mobilization
-Emergency instructions	-Reception and Care	

<u>RECOVERY:</u> A short-term activity to return vital life-support systems to minimum standards and long-term activity designed to return life to normal or improved levels. . General measures include:

-Crisis Counseling	-Public Information	-Temporary Housing
-Debris Clearance	-Damage Assessment	-Audits
-Disaster Declaration/Assistance	-Disaster Loans/Grants	-Reconstruction
-Assess Emergency Plans	-Unemployment Assistance	-Demolition

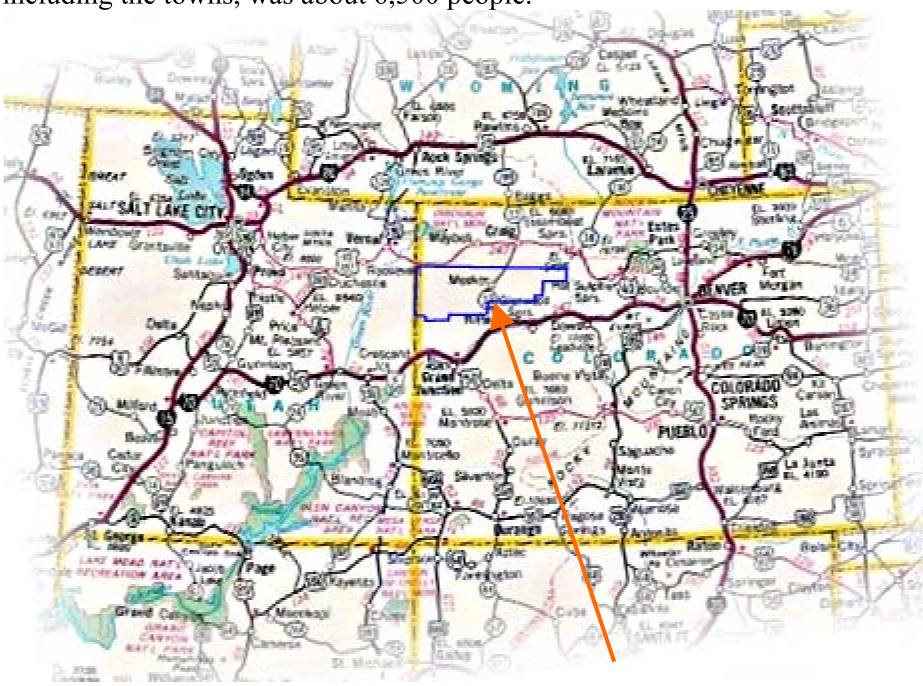
This document is the foundation for understanding the character of the natural hazards faced in the county and the types of actions that can be taken to mitigate those hazards. If successfully addressed the situations outlined in this document should be dramatically changed and the county will face less financial and human cost than if these problems are otherwise ignored.

Part II

Profile

Location

Rio Blanco County is in northwestern Colorado (figure 1) roughly 250 miles west of Denver and 250 miles east of Salt Lake City. The county is approximately rectangular in shape and has a maximum east - west distance of about 108 miles. The total area of Rio Blanco County is approximately 2.174 million acres or 3,263 square miles; thus, Rio Blanco County could encompass the combined areas of Rhode Island and Delaware. The county has two incorporated towns; Meeker, the county seat in eastern Rio Blanco County, and Rangely in western Rio Blanco County (map 1). In 1997, the population of the entire county, including the towns, was about 6,500 people.



Map 1. Location of Rio Blanco County

Geology

Western Rio Blanco County is in the north-eastern part of the Colorado Plateau physiographic province; eastern Rio Blanco County lies within the north-central part of the Southern Rocky Mountains physiographic province. The Grand Hogback, a monoclinic structure of steeply dipping sedimentary strata, traverses the county in a general north-south direction near State Highway 13 and separates the two major provinces. East of the Grand Hogback and the Meeker area, the White River uplift has raised the land to elevations ranging from about 6,000-12,000 feet. Subsequent stream and glacial erosion of this topographic high has exposed some of the oldest rocks in the county. West of the Grand Hogback, the Piceance Basin forms the principal geologic structure in the west central part of Rio Blanco County. The basin extends from the Grand Hogback westward to Cathedral Bluffs and contains sedimentary strata rich in oil shale, gas, and alkaline minerals. West of Cathedral Bluffs, in the most western parts of Rio Blanco County, the geologic landforms are controlled mostly by an anticlinal structure known as the Douglas Creek arch. The axis of the arch trends north - south and the arch contains significant resources of recoverable gas and oil.

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Surface geology in Rio Blanco County is mostly sedimentary rocks ranging in age from the Paleozoic (230-600 million years ago) to the Cenozoic (present to 63 million years ago). Paleozoic and Mesozoic (63-230 million years ago) sedimentary rocks are most common in the eastern third of the county; Mesozoic and Cenozoic sedimentary rocks dominate in the northern, central, and western parts of the county. During the last half of the Cenozoic Era, extrusives of mostly basaltic composition intermittently covered exposed rocks along the crest of the White River uplift. These volcanics are still evident (Flat Tops area) as resistant rock layers that cap older strata in the eastern parts of the county. Cretaceous and Tertiary (1-63 million years ago) shales and siltstones are common in the central and western part of the county and are generally less resistant to erosion than the rocks of the White River uplift.

Unstable slopes and valleys is a hillside or cliff or area that is susceptible to landslides, mudflows, rockfalls, or accelerated creep of slope-forming materials. Unstable slopes occur naturally and are widespread in Rio Blanco County. Most unstable slopes consist of weathered sedimentary strata and/or recent colluvium deposits that move downhill in response to gravity. Unstable slopes can be active or inactive. Slope failure can be initiated by a change of conditions, either natural or man induced. Natural factors contributing to slope instability include weathering and erosion, changes in the hydrologic characteristics of the hillside, loss of vegetation cover, earthquakes, and the slow natural deterioration of slope strength. Artificial factors that can undermine slope strength are cut and fill operations, alteration of surface drainages, excessive irrigation, removal of vegetation cover, blasting, and vehicular traffic.

Ground subsidence and valley floor erosion is the sinking and loss of land surface caused by rock failure over man-made or natural underground voids and erosion of soils. Subsidence may occur abruptly or gradually over many years. Subsidence is common above or near abandoned underground mines or where groundwater or dissolved materials have been removed. Natural cavities form when groundwater dissolves and transports the minerals gypsum, halite, or limestone from geologic structures. Man creates voids by drilling and mining. Rapid and massive valley floor removal can occur when water saturated soils and strata are subjected to erosional and sediment transport activities during major run off events. Subsidence and valley floor erosion can result in serious damage to surface structures, irrigation ditches, and underground utilities and pipelines. In Rio Blanco County, some local subsidence has occurred in Mesozoic age strata that contain evaporite deposits. Sinkholes have been noted near the confluence of Fawn Creek and the White River. Where subsidence is severe or predictable, complete avoidance is probably the most advisable course of action. In some cases, special structural designs can compensate for minor movement. In general, agriculture, parklands, or other open space land uses are compatible within subsidence areas.

Soils are the foundation for most land uses. Any activity or project should begin with an evaluation of the soil types and mechanics. All soils within Rio Blanco County have been surveyed and mapped. Two soil surveys have been completed in the county. The Rio Blanco Soil Survey (USDA, 1982) covers private and BLM lands. The Flat Tops Survey covers the National Forest areas and some private land. At present, only the Rio Blanco Soil Survey has been published. Most soil units in Rio Blanco County have varying limitations for land uses. Common soil characteristics that may cause hazards and/or limitations for selected land uses include: shrink-swell, frost action, soil strength, piping, excessive settling, corrosivity, stoniness, soil depth, and permeability.

When a development site use is planned, the soil survey will provide general information on potential hazards and limitations. An on-site soil investigation is encouraged to define if mitigation measures should be included into the overall design. Most soil hazards and limitations can be mitigated through the proper management and control of water and moisture within the soil profile.

Meteorology and Biomorphism

The rugged topography of western Colorado causes large variations in climate within short distances, and few climatic generalizations apply to the whole area. At the summits of mountains, temperatures are low, averaging less than 32° F over the year. Snow-covered mountain peaks and valleys often have very cold nighttime temperatures in winter, when skies are clear and the air is still – occasionally to 50° F below zero. Summer in the mountains is a cool and refreshing season. At typical mountain stations the average July temperature is in the neighborhood of 60° F. The highest temperatures are usually in the seventies and eighties, but may reach 90° F to 95° F. Above 7,000 feet, the nights are quite cool throughout the summer, while bright sunshine makes the days comfortably warm. The lower western valleys of the region are protected by surrounding high terrain, and have a greater uniformity of weather than the eastern plains. They experience high summer temperatures, comparable to those of the eastern plains, while average winter temperatures are somewhat lower than at similar elevations in the plains, due largely to the relative infrequency of chinook of other warming winds.

Precipitation west of the Continental Divide is more evenly distributed throughout the year than in the eastern plains. For most of western Colorado, the greatest monthly precipitation occurs in the winter months, while June is the driest month. In contrast, June is one of the wetter months in most of the eastern portions of the State.

The climate of Rio Blanco County is continental, characterized by dry air, sunny days, clear nights, variable precipitation, moderate evaporation, and large diurnal temperature changes. Climate is mostly semiarid/high desert in the lower elevations in the western half of the county and along the Utah border. Climate becomes transitional near Meeker and is alpine in the higher elevations of Piceance Basin and eastern Rio Blanco County. Blizzards and extremely frigid conditions occur occasionally (usually due to continental arctic air masses), while severe weather conditions such as tornados and damaging hail are rare.

Changes in topography cause considerable variations in local temperatures, precipitation, and surface winds. Variations in annual precipitation in the county primarily are due to orographic (mountain related) control. Annual precipitation ranges from less than 10 inches near Rangely to greater than 50 inches near Marvine Peaks in eastern Rio Blanco County. Most of the county receives an average of 10-20 inches of precipitation per year. Snowfall amounts vary from about 30 inches of snow at the lower elevations to 180 inches of snow at the Marvine Ranch. Most mountainous areas typically receive 30-50 inches of annual snow pack.

Seasonal and daily temperatures vary with elevation and, to a lesser extent, local microclimates. Daily temperatures (in degrees Fahrenheit) in summer usually range from the upper 40's to the 80's (in mountain terrains) and mid 90's (western valleys). In winter, cold air commonly accumulates in the valleys. Maximum daytime temperatures in winter typically range from 10 to 40 degrees; nighttime temperatures commonly average 20-30 degrees colder than daytime temperatures. Extreme temperatures have ranged from -48 degrees (Little Hills in 1963) to 104 degrees (Rangely in 1954). At the higher elevations, freezing temperatures are possible throughout the year and snow may accumulate from October to May. At lower elevations, freezing temperatures and snow accumulation are likely from October to April. Prevailing winds in the upper levels of the atmosphere are mostly from the southwest, but local air movements are strongly influenced by topography.

Natural vegetation cover in the county at elevations generally greater than 7,000 feet primarily consists of conifer and aspen forests; pinon pines, junipers, mixed grasslands, and sagebrush predominate at elevations generally less than 7,000 feet. The conifer and aspen forests are common in the eastern parts of the county and the high elevations along the rim of the Piceance Basin. Pinyon pines, junipers, mixed grassland, and sagebrush are common in the central parts of the county; sagebrush, sparse growths of grasses, pinyon pines, and juniper are typical in the western parts of the county. Irrigated and dry-land crops of grains, mixed grasses, and alfalfa hay are grown in the central parts of the county and along stream valleys throughout much of the county.

<u>Avalanche</u> is the rapid down slope movement of snow, ice, and associated debris. Avalanches start most frequently on slopes with average gradients of 58 to 100 percent. Leeward slopes are prone to avalanches because wind packs large amounts of snow on ridge tops. Northern slopes are prone to avalanches because the lack of sunlight prolongs snow instability. Avalanches are sporadic and may occur at the same location often or only once every 5 to 15 years. Long-term observation is the best way to establish avalanche frequency, size, and danger. Agriculture and recreational activities during non-avalanche months are appropriate land uses in avalanche prone areas; residential structures are inappropriate in avalanche prone areas.

<u>Wildfire</u> is an uncontrolled fire that may constitute a significant hazard to public health or property. Most of Rio Blanco County is subject to destructive wildfires, especially when winds are great and drought exists. Isolated areas that have vegetation, but lack roads or firebreaks, are more susceptible to serious wildfire damage. The expansion of recreation development and activities is expected to increase wildfire danger within the county.

Hydrology

The White River is a principal river in northwestern Colorado and the main source of water in Rio Blanco County. Most water (about 78 percent of the annual discharge) in the White River originates from snow pack that accumulates in the high mountain elevations of the White River uplift in eastern Rio Blanco and Garfield Counties. The mainstream of the White River begins at the confluence of the North and South Forks near Buford, and flows from an alpine climate westward through transitional climates near Meeker into a semiarid climate in western Rio Blanco County. Tributary streams east of Meeker mostly flow throughout the year (perennial) or seasonally (intermittent). Except for Strawberry, Piceance, Yellow, and Douglas Creeks, tributary streams west of Meeker mostly flow in response to storm events or occasional snowmelt (ephemeral). The drainage area of the White River at the Colorado-Utah State line is 3,680 square miles and the annual discharge normally ranges between 400,000-700,000 acre-feet.

<u>Groundwater</u> in Rio Blanco County mostly is from bedrock aquifers contained in the strata of the Mesa Verde formation (Cretaceous Period) and in the fractured rocks of the Green River and Uinta formations (Tertiary Period). Additional groundwater can be found in the valley fill (alluvium) of the White River and its tributaries. Springs that discharge water mostly from near surface aquifers are numerous and widespread in the county; most groundwater, however, is pumped from wells.

<u>Flood</u> in Rio Blanco County are most commonly caused by snowmelt, ice jams, and convective thunderstorms. Spring runoff from snowmelt in the watershed east of Meeker accounts for the greatest sustained stream flow in the White River. Local flooding can occur near ice jams that obstruct normal channel flow in winter and from runoff from intense thunderstorms. The largest recorded flood in Rio Blanco County occurred along the White River on May 25, 1984. At the time, the maximum discharge in the river near Meeker was about 6,950 cubic feet per second (cfs). By comparison, the minimum stream flows recorded in the White River near Meeker are less than 100 cfs.

<u>Thunderstorms</u> also can cause severe flooding, especially in the tributary basins of the White River. Yellow Creek, normally a small stream in Piceance Basin, had an estimated instantaneous peak discharge

of about 6,800 cfs on September 7, 1978. This unusual event was caused by a severe local thunderstorm. The stream flow of the brief event rivals the record flood of 1984 on the White River.

Federal flood control projects in Rio Blanco County are nonexistent except for the small impact of Kenney Reservoir east of Rangely. This reservoir was not constructed for flood protection purposes and has no significant effect on the 100 and 500-year floods. However, the reservoir may have reduced or eliminated flooding problems caused by ice jams near Rangely.

Rio Blanco County has participated in the National Flood Insurance Program (NFIP) since 1990. The program is designed to minimize the loss of life and property by identifying flood prone areas and regulating new development in areas likely to flood. Participation in NFIP guarantees that property owners in flood prone areas can obtain floodplain insurance. Without the county=s participation in NFIP, property owners would be unable to purchase flood insurance. In addition, all federally connected loans, such as HUD, VA, FDIC, Fannie Mae, Farmer's Home Administration, Federal Housing Administration, Small Business Administration loans, etc., also would be unavailable to residents without county participation. In return, the county is obligated to ensure that new development within the 100-year floodplain will be constructed in ways to minimize danger to life and property.

The 100-year flood, as defined by the Federal Emergency Management Agency (FEMA) and adopted by FEMA and Rio Blanco County is the base flood used for floodplain management purposes. Flood Insurance Rate Maps (FIRM), prepared for Rio Blanco County by FEMA identifies the 100-year floodplain boundaries. Rio Blanco County has adopted floodplain regulations that apply to development in flood hazard areas.

As generally defined, the 100-year floodplain is that area adjacent to a stream channel that is inundated by unobstructed large flows that occur, on average, once every 100-years. The floodway includes the normal channel of the stream plus that part of the adjacent inundated areas of the floodplain where, if stream velocities are obstructed, would create a damming or back water effect. This effect could produce a substantial increase in water levels; thus, inundating areas normally outside the 100-year floodplain. The area between the floodway and the 100-year floodplain boundary is defined as the floodway fringe. The floodway fringe is that area of the floodplain where velocities are small and obstructions can occur without increasing water surface elevation of the 100-year flood by more than one foot.

Development (including residences) is only allowed in the floodway fringe (floodplain) after receipt of approval (floodplain development permit) by the county. Development is generally prohibited in the floodway. The request for approval (permit) will be based on plans that clearly show, and (when necessary) are certified by a licensed professional engineer or architect, that indicate the development will not create a flood hazard and comply with Rio Blanco County standards for management of development in the floodplain.

Wildlife

Wildlife and their habitats are an important part of the natural resources that lures hunters, anglers, and tourists to the county. Wildlife and open spaces of the White River Valley are part of what create the quality of life for those residents who choose to live in Rio Blanco County. In some cases they are the very reason people choose to live in this area. The tourism industry is dependent on wildlife, primarily the hunting of elk and deer and fishing, and adds to the stability of the county's economy. Economic benefits include income from hunting and fishing lodges, outfitters, ranchers, and all types of local businesses.

Elk herd population in the White River is the largest in the world. Migratory elk in the White River area move seasonally from high elevations in summer to lower elevation ranges in winter. Since the 1960's, elk have expanded their range throughout most of Rio Blanco County.

Mule Deer population in the Piceance Basin has been referred to as the largest migratory deer herd in North America. Herd numbers in the 1990's are down substantially from previous years. During fall, thousands of deer migrate from the White River National Forest and cross Colorado State Highway 13 to winter in the Piceance Basin. Similar migrations occur from the Dunckley Flattops and Sleepy Cat Peak areas into lower elevations. Migrations are reversed in spring as deer return to their summer ranges. Large numbers of road kills along Highway 13, County Road 5, County Road 7, and Highway 64 are common during these migrations. Mule deer summer at higher elevations, mostly on USFS and BLM lands. In winter, mule deer are commonly found on both private and BLM lands. Resident non-migratory deer are also found throughout the county. These deer stay in the same general area year round. The number of resident deer is small compared with migratory deer.

Mule deer and elk migrate large distances between summer and winter ranges. Often times these movements cross private lands and highways. Protection of migration corridors is imperative in order to ensure continued access to summer and winter ranges. Blockage of these corridors would restrict the ability of these animals to forage during different times of the year and may lead to additional game damage on private lands adjacent to corridor areas.

Aquatic species that are predominate in the White River basin are the Colorado River cutthroat trout and mountain whitefish which are native salmonids. The Colorado River cutthroat is one of four sub-species of cutthroat trout native to Colorado and is found in high elevation lakes of eastern Rio Blanco County. Recent decreases in populations have intensified management plans to keep the Colorado River cutthroat off the threatened and endangered list. The mountain whitefish occupy the White River upstream of Meeker. Both species provide major sport fisheries in the county.

The Colorado squawfish inhabit the lower reaches of the White River in western Rio Blanco County and are unique to the Colorado River basin. The fish are listed by state and federal agencies as an endangered species and an active program is underway to recover this species. At times, the squawfish congregate immediately below Kenney Reservoir and special fishing management regulations are required for this area.

Fish species including northern pike, largemouth bass, bluegill, crappie, and rainbow trout have been introduced into impoundments such as Kenney Reservoir, Rio Blanco Lake, and Lake Avery. Together with the native salmonids, these fish provide excellent year-round angling opportunities that create job opportunities, commerce, and recreation for county residents.

To promote and protect the aquatic biology of the White River basin, it is imperative the county monitor and maintain the chemical, physical, and biological components of the aquatic environments. In addition, the county must be politically active with state and federal resource management agencies.

History

Archaeological data suggest that humans have occupied Rio Blanco County for approximately 12,000 years. Early inhabitants probably were hunters and gathers. Material remains of these early inhabitants, however, are limited and archaeological sites generally are small. Data indicate that significant changes in lifestyle occurred in the first millennium AD. Ancient fields suspected of growing corn and bean crops have been identified in aerial photographs. Also, small masonry structures, storage facilities, and "houses" built by people of the Fremont Culture 200 to 1250 AD occasionally are found. Recent analysis of pottery fragments suggests that the people of the Fremont Culture may have had periodic contact with the Anasazi to the south. Rock art associated with the Fremont Culture is common in the central and western portions of the county.

Around 1200 to 1300 AD, evidence of the modern Ute Nation first occurred in the archaeological record. Before the introduction of the horse, the Utes lived much like the people of the Fremont Culture. After the introduction of the horse in the 1590's, Ute culture changed noticeably and individuals began adopting many traits similar to those of the plains hunters. These traits included the utilization of the tepee, abundant beadwork, saddles, and horse racing.

Spanish period began when, in 1776, Spanish adventurers led by Fathers Escalate and Domingues became the first recorded white explorers to enter what is now Rio Blanco County. Entering from the south after crossing the Roan Plateau, they traveled down Douglas Creek and crossed the White River upstream of what is now the Town of Rangely. These Friars were seeking a route between Santa Fe, New Mexico and Monterey, California. A highway marker placed on State Highway 64 near Rangely by the Colorado Historical Society commemorates this expedition and marks the campsite of these explorers near the confluence of the White River and Douglas Creek.

Frontier period began when, in 1844, Captain J. C. Fremont traveled down the White River, possibly by boat. Although Fremont was seeking an easy route west to California, his primary purpose for the trip was military in nature. Major Powell, his wife Emma, his brother Walter, and six other men arrived on the White River in the winter of 1868-69 to survey the area. Camped in what is now called Powell Park, named in his honor, Major Powell lived with the Ute Indians and learned the Ute language and culture. As a result of this experience, Major Powell wrote the first known ethnography of a native American people. This ethnography later led to an appointment with the Smithsonian Institute as the first Director of the Bureau of Ethnology. Later Major Powell became one of the founders of the National Geographic Society and the first Director of the US Geological Survey.

The Predominate Indian tribe of the area was the Ute. Chief Ouray was an influential Ute chief at the time of the Meeker massacre and the subsequent expulsion of nearly all Utes from the White River Valley. Chief Ouray was unique in his ability to merge the civilizations of both the white man and Indian. Nathan C. Meeker and Thomas T. Thornburgh were the protagonists in the last true battle recorded between an Indian tribe (Utes) and the United States military. (Numerous clashes between Indian bands are recorded after this conflict, but none involved an entire tribe). The battle occurred at the base of Thornburgh Mountain near Milk Creek and ultimately resulted in the expulsion of nearly all Utes from the White River Valley and much tighter control of Indians on reservations.

Momentum for the Thornburgh battle began when Nathan Meeker, an idealist, gained a political appointment as Indian Agent for the White River Ute in 1878. Meeker's insistence on turning the Ute into his idea of utopian farmers triggered a string of hostile feelings between whites and the Native American tribe. Meeker moved the Indian Agency from a site upstream of the present Town of Meeker to a downstream site known today as Powell Park. Meeker thought the environment at Powell Park was better suited for farming and the monitoring of his charges. The Meeker Massacre occurred on September 29, 1879, when the frustrated Ute Indians killed Nathan Meeker and the ten civilian men employed by Mr. Meeker. The Town of Meeker is named after this famous Indian agent.

At the time of the Meeker Massacre, Major Thomas Tipton Thornburgh was the commanding officer of Fort Steele, Wyoming, the closest military post to the White River Agency. On orders from Major Crook, Thornburgh and his troops were sent to the White River Agency to protect Nathan Meeker and the Agency staff. While traveling to Meeker, Major Thornburgh and his troops were attacked by the Utes along Milk Creek near Thornburgh Mountain, later designated the Thornburgh Battlefield. Thornburgh was killed in the first volley of rifle fire.

Several sites relating to this conflict are of historic importance. The first is Powell Park, the site of Major John Wesley Powell's cabin and later the site of the Ute Agency and Meeker Massacre. The second is the Thornburgh Battleground, designated as a National Historic Site on August 22, 1975. The third site is the Officer's Quarters on the White River. Five cottonwood log structures built in 1879-1880 became the nucleus of the town of Meeker. (National Historic Site status is now pending.) The houses were occupied by officers at the garrison and faced the parade ground, now the court house square and the elementary school site.

Teddy Roosevelt detailed his hunts for lion and bobcat in Rio Blanco County in his book *Life of an American Hunter*. This experience helped convince Roosevelt that the preservation of public lands for conservation reasons was in the national interest. Roosevelt spent one night in the Meeker Hotel where he met with Reverend Handel from St. James Episcopal Church. The rest of Roosevelt's stay was spent north of the White River hunting on what is commonly known as the Keystone and Big Rock Ranches. He returned one month prior to his succession as President to fish in the White River Valley on the Pothole Ranch.

Population

The population in Rio Blanco County is stable having fluctuated little in the last ten years. The Colorado Department of Local Affairs estimates that 5,986 people live in the County compared with 5,972 residents at the time of the 1990 U.S. Census. Of the estimated 5986 residents roughly 4338 persons are estimated to live within the incorporated limits of Meeker (2,242) and Rangely (2,096). Census data indicate that more people live outside of incorporated town limits in eastern Rio Blanco County than in the western half of the county. The relatively equal population distribution between the eastern and western parts of the county has had both social and political implications.

The population of the county generally has remained steady over past decades in spite of numerous energy boom and bust cycles. The population was greatest (7,621) in 1983 during the height of an oil shale boom. Following the oil shale bust, the population steadily decreased for 7 years and was 5,972 in 1990. Since 1990, the population has changed little. Given that major projects for nahcolite have been completed and assuming these job opportunities have been absorbed into the community the population can be assumed to be stable for the foreseeable future. The population can also be assumed to be in a position of sustainability, as recent developments have not shifted population or housing stocks. These will be monitored as development of the county's natural resources (oil, gas, oil shale, coal, and nahcolite) may cause disruption as oil shale has in the past.

Housing

A total of 2,803 single and multi-housing units in Rio Blanco County, averaging 2.67 persons per unit, were identified in the 1990 U.S. census. At the time, 1,441 units were owner-occupied and 740 units were renter-occupied. Vacant housing totaled 622 units, of which 205 units were for seasonal, recreational or occasional use. In addition, 60 subsidized housing units were identified in the county. Given present population is relatively the same the housing stock is considered stable. The only area where housing has changed is in second homes in the upper White River which does not show up in population.

Of the 2,803 housing units identified in the 1990 census, selected data indicate that 2,082 units obtained water from a public system or private company and 493 units received water from private wells.

Similarly, data for sewage disposal indicate that 1,997 units were connected to a public sewer system and 753 units utilized private sewage disposal systems. Natural gas supplied by utility companies was common and used to heat 1,387 housing units. Other less common heating fuels included bottled or LP gas (220 units), wood (220 units), and electric heat (218 units). Coal was identified as the major heat source of 100 units.

Land Ownership

Settlement in Rio Blanco County has been along the major river and stream drainages. This pattern has been influenced mostly by the availability of water for domestic and agricultural use, level ground suitable for agriculture, and the availability of private land ownership. These influences probably will continue into the foreseeable future, with residential development displacing agricultural fields in some areas.

The distribution of public and private lands greatly influences development patterns in Rio Blanco County. The United States Forest Service (USFS) manages approximately 17 percent of the land in the county, mostly in eastern Rio Blanco County. The Bureau of Land Management (BLM) manages 56 percent of the county land, primarily in the central and western portions of the county. Private lands account for 24.4 percent of the county land area, and are primarily in the main and tributary valley areas of the White River, South Fork of the White River, and Piceance Creek. The Colorado Division of Wildlife (CDOW) owns 44,237 acres or 2.1 percent of the total area of Rio Blanco County. Land ownership is tabulated in table 1.

Table 1: Statistics of land ownership, Rio Blanco County

Pvt. (Acres)	Pvt. (%)	BLM (Acres)	BLM (%)	USFS (Acres)	USFS (%)	CDOW (Acres)	CDOW (%)	Other (Acres)	Other (%)	Total (Acres)
503,312	24.4%	1,150,000	56%	359,302	17%	44,237	2.1%	779	.05%	2,063,694

Historically, urban development has concentrated in or near the towns of Meeker and Rangely. This pattern reflects the efficient use and distribution of public services, such as sewer and water, and has discouraged sprawl into wildlife and open areas while maintaining viable agricultural operations. Recent increases in residential and recreational activities along the White River east of Meeker have displaced or encroached upon traditional agricultural and wildlife areas. In contrast, because the area is largely surrounded by BLM lands, future expansion of the Town of Rangely into the surrounding area may be limited in several directions.

Economy

The economy of Rio Blanco County is based mostly on the use and development of natural resources. Presently, the mining of coal, oil, natural gas, and the appreciation of wildlife and scenic beauty provide the foundation of economic activities within the county. Based on 1995 data, the Colorado Department of Local Affairs has provided distribution estimates of the major economies in Rio Blanco County (figs. 4 and 5). Mining (including oil and gas extraction) is the principal economic activity in the county in terms of both employment (61 percent) and direct income (78 percent). Coal, nahcolite, and sand and gravel mining account for approximately 57 percent of employment and 60 percent of direct income within the industry. In contrast, oil and gas extractions account for approximately 43 percent of the employment and 40 percent of direct mining income.

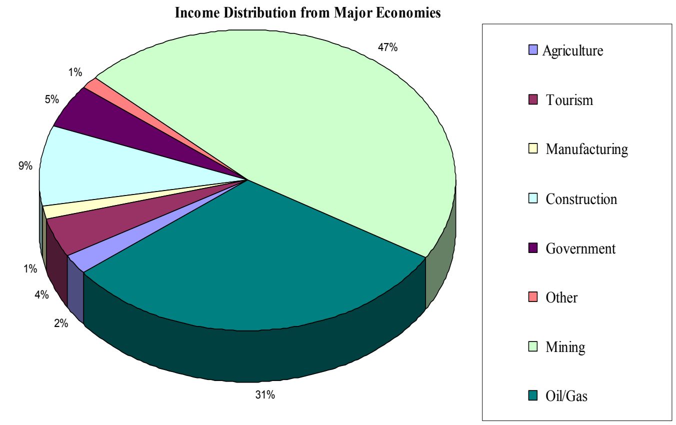

Figure 4: Income distribution from major economies, Rio Blanco County.
(Data Source: Colorado Department of Local Affairs, 1997)

The distributions of assessed property tax valuations, however, (fig. 6) are different from direct income distributions and basic employment (figs. 4 and 5). Historically, the oil and gas industry has been the principal contributor to Rio Blanco County's property tax valuations. In contrast, the mining industries associated with coal and minerals were assessed at only 8 percent of the total county property value in 1996. This difference occurred because most jobs associated with coal mines are located in Moffat County while most jobs associated with oil and gas operations are located within Rio Blanco County. Because the economy of Rio Blanco County presently is dominated by two major coal mines and the oil and gas industry, severe shocks to the local economy could occur if these industries suffer a reduction in activity.

Tourism is the second largest economy in the county, providing 16.1 percent of total employment and 4.3 percent of total direct income. Recreation and tourism have grown significantly in recent years. Motels, lodges, and places for eating and drinking have accounted for the greatest growth. Hunting and fishing provide the foundation for most tourism. In addition, the designation of County Road 8 as a scenic byway in 1991 has increased general touring of the area.

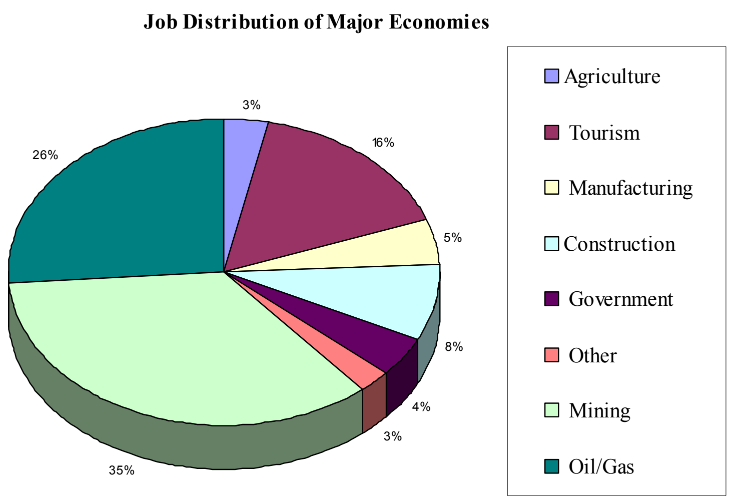

Figure 5: Job distribution of major economies, Rio Blanco County.
(Data Source: Colorado Department of Local Affairs, 1997)

Other contributors to the economy include construction (both light and heavy), manufacturing, government employment, and agriculture. Construction accounted for approximately 8 percent of total employment, manufacturing approximately 4.7 percent, government approximately 4.3 percent, and agriculture approximately 3.3 percent.

The interrelationships of recreation and tourism, wildlife, and agriculture in Rio Blanco County are significant. Much of the local recreation and tourism industry is based on wildlife and hunting, especially hunting elk and deer, and trout fishing. Populations of elk and mule deer largely depend on access to private agricultural lands in the valleys for winter survival. In return, most ranchers receive considerable benefit from wildlife activities through the leasing of hunting rights, outfitting, and the boarding of hunters. The open spaces associated with traditional agriculture and the scenic views of herds of deer and elk from county roads are valuable assets to tourism and a primary reason for the designation of County Road 8 as a scenic byway. The preservation of agricultural open spaces in the major valleys will be necessary to maintain the recreation and tourism industries in the county.

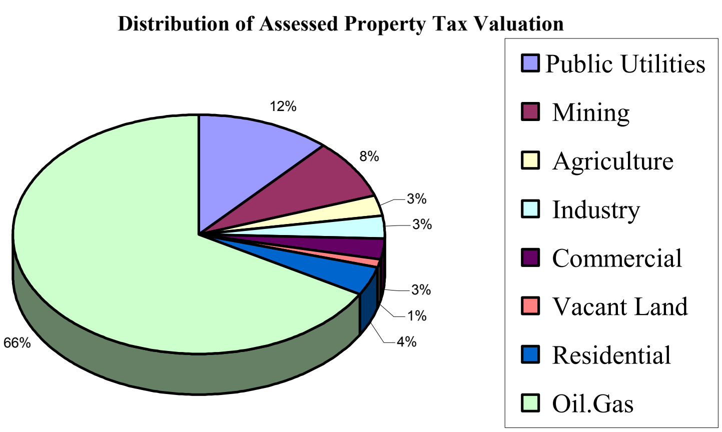

Figure 6: Distribution of Assessed Property Tax Valuation
(Source: Rio Blanco County Assessor's Office, 1996)

Agriculture

Traditionally, agriculture has been an important element of the customs, culture, and economy of Rio Blanco County and is expected to remain important for the foreseeable future. Agriculture in the county today is diversified and fairly stable and consists mostly of ranching (cattle and sheep) and the growing of irrigated and non-irrigated hay, pasture, and field crops. Approximately 4 percent of the county is irrigated cropland, about 1.6 percent is non-irrigated cropland, and about 61 percent is rangeland. Approximately 546,000 acres of land in Rio Blanco County are classified as agriculture. Of this amount, 52,000 acres are classified as cropland. Harvested cropland is composed of alfalfa, hay, and wheat that amount to roughly 26,000 acres. Irrigated crops are mostly alfalfa and grass hay; some oats also are grown. Most irrigation occurs by contour ditch flooding; sprinkler systems are used in small areas. Wheat and barley are the most common non-irrigated crops. In 1992, 41,600 tons of hay was produced from 19,500 acres at an average of 2.15 tons per acre.

The raising of livestock is an important part of the agricultural industry in Rio Blanco County. Ranches primarily are cow-calf and ewe-lamb operations. In 1992, there were roughly 35,000 cattle and 35,000 sheep raised in Rio Blanco County. Maintaining livestock grazing on public lands is an important concern of the livestock industry in the county.

In 1992, the value of agricultural sales (livestock and crops) totaled approximately 15 million dollars. The agricultural industry, however, provides many benefits to the community beyond the direct value of produced products. The agricultural community has had an important stabilizing influence on the local economy through its many diverse activities. Open space, so important to the character of the area, to tourism, and to wildlife habitat are side benefits of a healthy agricultural economy. While commodity contributions of agricultural products have declined in relative importance, the land, open space, wildlife and other natural resources of the area continue to play a fundamental role sustaining the region=s economy. As recreation, tourism, and economic diversification grow, the foundation for this growth will be increasingly dependent on the quality and management of the environment and surrounding communities.

In recent years the number of farms and ranches has declined and the size of individual units has increased. The demand for agricultural land for rural residential and recreational uses continues to increase along the White River and elsewhere. In general, agricultural activities are compatible with tourism, hunting, fishing and recreation. Poorly managed rural residential and commercial development, on the other hand, tend to conflict with agricultural and recreational uses. The construction of homes in agricultural lands serves to displace agriculture by raising land prices and can cause conflicts among residents of the county.

Tourism

Tourism is the second largest economic resource in Rio Blanco County. Although mining tends to be cyclic with variability based on the market and resource reserves, tourism has provided stability and diversification to the local work force. Increased tourism has been identified by various business interests as one of several strategies to generate more jobs and income for residents of the county.

Hunting and fishing traditionally have been the major source of income from tourism. Since the designation of County Road 8 as a scenic byway in 1991, however, general tourism has increased, especially in the eastern parts of the county. In recent years, the promotion of winter recreation has extended tourism year round. Winter activities include snowmobiling, cross-county skiing, snowshoeing, ice fishing, and support services provided by local guest ranches.

Rio Blanco County has extensive recreational and historic resources that attract visitors to the area. Because BLM and USFS lands make up 73 percent of the total land area of the county, multiple use activities and a wide variety of outdoor adventures are available. Many trails for snowmobiling, hiking, horseback riding, biking, cross country skiing, and scenic driving are easily accessible on these lands. Education in western history is actively promoted by the White River Museum in Meeker and the Rangely Museum. The central and western parts of the county are in the heart of the historic Fremont Culture, and the Meeker area is unusually rich in the history of the Ute Nation. Presently, references to these historic resources are part of the Canyon Pintado National Historic District and the Meeker Massacre Pageant. Travelers on route to major state or national tourist attractions such as Steamboat Springs, Glenwood Springs, Aspen, and Dinosaur National Monument frequently find Rio Blanco County a pleasant and relaxing experience.

The Colorado Division of Wildlife (CDOW) has developed a computer model to estimate economic impacts of hunting and fishing statewide and for individual counties. Data indicate that 27,546 people hunted big game in Rio Blanco County in 1994; only 976 of these hunters were residents of Rio Blanco. An annual influx of approximately 26,000 big game hunters into Rio Blanco County creates a tremendous economic benefit to the county. Table 2 summarizes the estimated direct expenditures in Rio Blanco County derived from hunting and fishing activities in 1994. Estimates indicate that $10,502,000 was contributed to the economy from big game hunting in 1994. Small game hunters added another $754,000, and anglers added $1,737,000 to the county's economy. Expenditures include the sales of hunting and fishing licenses, food, lodging, gas, etc. In addition to direct expenditures, secondary expenditures that result from the circulation of direct dollars in the economy added another $9,698,000 to the county's economy. Assuming 1994 was a typical year, total expenditures by hunters and anglers could add between $20-$25 million dollars annually to the economy of Rio Blanco County.

Table 2. Resident and non-resident direct and secondary expenditures from hunting and fishing activities, Rio Blanco County - 1994.

Deer	Elk	Other Big Game	Small Game	Fishing	CDOW Direct	Total Direct	Secondary	Total
$5,307,000	$5,121,000	$74,000	$754,000	$1,737,000	$1,161,000	$14,154,000	$9,698,000	$23,852,000

In addition to the traditional uses of the wildlife resource (hunting and fishing), the Colorado Board of Tourism estimates that scenic viewing of wildlife alone could account for 20% of the general tourism in Colorado. Taken as a whole, activities related to wildlife provide a tremendous benefit to the economy of Rio Blanco County.

Energy Resources and Mining

The large energy and mineral resources in Rio Blanco County are valuable at the national, state, and local levels. Rio Blanco County presently ranks No. 1 in the production of oil and No. 4 in the production of natural gas in Colorado. Most oil and gas is produced in central and western Rio Blanco County. The Piceance Basin in central Rio Blanco and western Garfield Counties contains the world's largest known deposits of oil shale and nahcolite. An estimated 1.2 trillion barrels of shale oil are contained within the sediments of the Green River Formation in Piceance Basin. In addition, large coal reserves are located in two major fields in the central and western parts of Rio Blanco County. Several other minerals, such as halite and dawsonite, also have development potential.

Mining and energy resource industries historically have been major employers in the county. Most energy related jobs have provided higher-than-average wages. In addition, energy resource development and mining are a significant component of the local tax base. Approximately 69 percent in 1994 and 67 percent in 1995 of the county's assessed value was derived from oil and gas activities. The percentage decrease that occurred between 1994 and 1995 was largely the result of the declining production of oil near Rangely. The assessed value of energy property mostly is dependent on oil and gas production and unit price.

Past development of energy resources and mining has raised numerous concerns in western slope communities and in Rio Blanco County in particular. Large projects have the potential to overwhelm small communities with a large influx of new residents, many from out-of-state. Typically, large investments in infrastructure for roads, schools, social services, housing, etc. are required of local communities impacted by such projects. Addressing these impacts while maintaining the social and economic integrity of the local communities will be a major challenge as these projects develop.

Oil most commonly is recovered from wells that penetrate geologic structures that trap large collections of hydrocarbons. Two major sources of oil in Rio Blanco County are the Rangely Weber Sand Unit and the Wilson Creek Oil Field.

The Rangely Weber Sand Unit is an oil field that covers almost 20,000 acres and was estimated to contain 1.9 billion barrels of oil when it was discovered in 1933. It is the largest oil field in Colorado. Oil production occurs in a general 11- by 5-mile area northwest of the Town of Rangely. By 1949, the field contained 478 wells on 40-acre spacing. After several years of large production, reservoir pressures began to decline. To increase the recovery of oil, the field was unitized in 1957 with Chevron designated as operator. Both public (BLM) and private lands were included within the unitized field. The unitization allowed water flooding as a secondary recovery method. From 1964 to 1986, injection wells were drilled on 20-acre and 10-acre spacing to boost recovery. In 1986, 543,000 barrels of water per day were injected into 300 active injection wells.

By 1986, 692 million barrels of oil had been recovered from the field and 31,000 barrels of oil were sent daily to refineries in Salt Lake City. Using production methods common in 1986, the estimated ultimate recovery was 789 million barrels of oil, or 42 percent of the original 1.9 billion barrels in place. To increase recovery and save the field, Chevron looked for new technologies.

A tertiary recovery method that used carbon dioxide ($C0_2$) gas injection was initiated in 1986 to recover the residual oil. Many facilities were constructed to implement the $C0_2$ project. A high pressure pipeline was constructed to transport $C0_2$ gas from Exxon's Shute Creek gas plant near LaBarge, Wyoming to the Rangely field. Over 100 miles of $C0_2$ injection and gas gathering lines were laid throughout the oil field. A gas compression facility having eleven 4,000 horsepower compressors was built to reinject produced $C0_2$. Roughly $158 million in capital investment was required for the project. Today, all but a small portion of the field (in the Town of Rangely) has been injected with $C0_2$. The $C0_2$ project is expected to recover an additional 107 million barrels of oil, or an additional 7.2 percent of the original oil in place. Expectations are that oil production will continue to decline over the next decade.

The Wilson Creek Field, although about one-tenth the size of the Rangely Weber Sand Unit, is the second largest oil field in Colorado and Rio Blanco County. The field is about 10 miles north of Meeker. Oil production is from the Sundance and Morrision Formations of Jurassic age and the Minturn Formation of Pennsylvanian age. Like the Rangely Oil Field, oil production from the Wilson Creek Oil Field is in decline.

Natural gas is produced from wells that tap geologic structures where large quantities of gas collect. Most gas is a combination of methane, ethane, propane and small amounts of heavier molecules. Normally, propane and the heavier molecules are removed before the gas is sold to consumers. Coal bed methane is a natural gas derived from coal beds. The gas generally contains a greater proportion of methane and ethane than found in the mixture of "conventional" natural gas.

Natural gas reserves are widespread in the county. Presently, ten major fields account for approximately 85 percent of the natural gas production in Rio Blanco County. The fields, located in the central and western parts of the county, are known as the Dragon Trail, Rangely, Douglas Creek, Cathedral, Douglas Creek West, Southwest Rangely, Piceance Creek, Hells Hole Canyon, Douglas Creek North, and Lower Horse Draw fields. Presently, coal bed methane production comes mostly from the White River Dome Field north of the intersection of County Road #5 and State Highway 64. In the 1990's, annual production of conventional natural gas in Rio Blanco County was about 30-40 million cubic feet (MCF) compared to 2-3 MCF for coal bed methane.

Natural gas activity tends to fluctuate with price but generally has increased since the late 1980's. This increased activity is expected to continue over the next decade. Historically, production was limited by the inability to transport large quantities of gas to major markets. Recent construction of major new pipelines and the repair and/or enlargement of existing pipelines has stimulated gas production in the area.

Impacts from natural gas development are more widely dispersed than the impacts from oil or coal development. Each gas wellsite requires an access road and, if producing, a connecting pipeline to a gathering system. Pipelines can extend long distances and may cross private lands, public roads, prime agricultural lands and irrigated fields, streams and rivers, and other pipelines. Unnecessary and redundant roads further increase impacts to wildlife and the land surface. The development of pipeline right-of-ways has been a factor in the spread of noxious weeds and, in the past, has caused significant impacts on agricultural production and operations. Most gas activity has been on remote public lands. Recent gas development, however, has encroached more on rural residential and agricultural areas.

Coal is produced from two major fields in Rio Blanco County. The Danforth Hills Field is north of Meeker and contains an estimated 416 million tons of recoverable coal reserves. The White River Field is in the general vicinity of Rangely and contains an estimated 327 million tons of recoverable coal reserves. The principal coal-bearing beds in both fields are within the Mesaverde Group of Cretaceous age.

The only coal presently mined within Rio Blanco County is from the Deserado Mine east of Rangely in the White River Field. This underground mine supplies coal to the Bonanza Power Plant in Utah. Colowyo Coal Company mines coal from the Danforth Hills Field but present mining occurs north of the county line in Moffat County. Although grading from the open pit mine extends into Rio Blanco County, no coal extraction presently is proposed in Rio Blanco County. Several closed coal mines in the Danforth Hills Field have the potential to reopen if economics become favorable.

In addition to the Danforth Hills and White River Fields, coal deposits have been identified in other areas of Rio Blanco County. However, the majority of these deposits are on BLM lands on which coal leases have not been granted. As a result, the development of coal on these lands is unlikely.

Oil Shale is found in the Piceance Basin in Rio Blanco and Garfield Counties and contains an estimated 1.2 trillion barrels of shale oil. The shale oil, along with associated deposits of valuable evaporates, are part of the Green River Formation of Tertiary age. Attempts to extract this oil from the shale deposits have occurred periodically for much of the 20th century. In the 1970's, a number of oil companies attempted to develop a shale-oil industry. The Synthetic Fuels Corporation (SFC), a quasi-government organization, was authorized in February 1981 to administer up to $88 billion of federal assistance for synfuels development. After production of about 5 million barrels of shale oil by several oil companies, these operations were abandoned in the mid 1980's.

Two major attempts to develop oil shale in Rio Blanco County occurred during the late 1970's and early 1980's at oil shale lease tracts C-a and C-b. The C-a tract originally was designed as an open pit mine in an area having an average overburden of 450 feet. The tract C-b lease was designed as an underground mining operation with an above ground oil shale retort. Three shafts at tract C-b were drilled to depths of over 1800 feet before the project was abandoned. Both lease tracts presently are maintained under an approved suspension mode established by the federal government.

Future development of oil shale could have a tremendous impact on Rio Blanco County. Population projections developed for the oil-shale industry in the 1970's and 1980's suggested that the population in each of the Towns of Meeker and Rangely could approach 30,000 people. Because of the projected increases in population, many of the small towns and surrounding counties made large investments in infrastructure in anticipation of growth from such projects. When the projects failed to develop, the local governments were left with the large residual costs in a time of depressed economies. Future large-scale projects will be reviewed closely by Rio Blanco County and will require the cooperation and financial support of the development industries to maintain impacts at manageable levels.

Nahcolite is found in the Piceance Basin which contains the world's largest known deposit of naturally occurring nahcolite (sodium bicarbonate-baking soda) and significant quantities of halite (sodium chloride) and dawsonite (an aluminum rich carbonate). Solution mining of nahcolite currently exists in the basin. Nahcolite and soda ash (sodium carbonate) are used worldwide for a wide variety of uses including: flue-gas scrubbing; waste-water treatment; the manufacture of glass, detergents, and cleaning solutions; pharmaceuticals; pulp and paper; baking; and as an animal-feed supplement. Halite (table salt) and dawsonite presently are not mined.

The BLM has indicated that approximately 223,000 acres in Piceance Basin potentially contain valuable resources of nahcolite. The total nahcolite resource of about 32 billion short tons is considered a major potential source of baking soda in the world market. The federal government presently has granted sodium (nahcolite) leases totaling about 16,000 acres in a rich saline zone near the north central part of Piceance Basin out of a total of 106,760 acres available for sodium resource leasing. A major sodium developer and lease holder has indicated that roughly 30,000 acres have practical developable value under present market conditions and technology for multi-mineral development.

The NATEC Sodium Lease consists of 8,300 acres near the geologic depositional center of the Piceance Basin. The leased area, issued in 1971, is above the richest and thickest section of sodium mineralization in the basin. The White River Nahcolite Minerals Company presently operates a 125,000 tons per year (design capacity) sodium-bicarbonate plant on this lease. Production began in 1991 utilizing hot solution recovery methods from waters circulated through horizontal cavities that were drilled at depths of about 2,000 feet below the land surface.

The Rock School Sodium Lease (1,320 acres) was issued in 1971 and is west of the NATEC Lease. The lease presently is undeveloped.

The Yankee Gulch Joint Venture Sodium Lease consists of 4,954 acres and is east-northeast of the NATEC Lease. The lease presently is under development. A large commercial plant may be constructed on the lease in the near future.

The Nielsen-Juhan-Hogle Sodium Lease is south of the NATEC Lease and consists of 2,200 acres. The lease presently is undeveloped.

The mining of nahcolite in the Piceance Basin has raised several concerns. Presently, nahcolite is trucked to a railroad line near the Town of Rifle in Garfield County. Increased production of this resource has the potential to strain the existing road network. Piceance Basin is roughly equally distant to the towns of Rifle, Meeker, and Rangely. In the past, a disproportionate percentage of the workers, offices, and economic benefits involved in the mining of Piceance Basin have gravitated towards Garfield and Mesa Counties. As a result, Garfield and Mesa Counties receive most of the economic benefits while Rio Blanco County must deal with most of the costs of development.

Sand, gravel, and stone extraction provides raw material for most construction and paving activities in Rio Blanco County. Sand and gravel deposits are found along parts of the White River and major tributary valleys. Other sources include, glacial outwash, widespread colluvial deposits at the base of rock outcrops, and alluvial fans. Large sand and gravel reserves occur near Meeker in the vicinity of Agency Park, Powell Park, and the Little Beaver area. Near Rangely, most sand and gravel occur in present and past river channel deposits in, and adjacent to, the White River. Other sources occur as terrace deposits on ancient floodplains adjacent to the White River and in tributary valleys downstream from Rangely. Limited sources also exist near County Roads 2 and 102. Building stone and riprap material are common throughout the county. Potentially, almost all resistant rock formations are a source of stone and riprap, although some are more suitable than others. Clay deposits are common within the Wasatch Formation and Mesaverde Group.

The continued availability of these building materials at economical prices is important for affordable housing, reasonable tax rates, and a strong and diverse economic base. To be economical, however, most construction rock must be mined close to where it will be used. Costs can double for every 50 miles the material is transported and increases in transportation costs are quickly reflected in greater construction costs for projects that use these materials.

Although of economic importance to the county, sand and gravel pits frequently are a nuisance to surrounding landowners. When improperly sited and/or operated, these mining activities have a detrimental affect on the daily lives of nearby residents, and can negatively impact surrounding property values. Rio Blanco County has received numerous complaints about sand and gravel pits. Complaints mostly are problems with dust, noise, visibility, truck traffic, and damage to roads.

To minimize problems, the proper siting of sand and gravel pits is mandatory. In eastern Rio Blanco County, sand and gravel deposits are common and site selections are flexible. Major concerns are site proximity to residential areas and visibility from major roads, especially from the County Road 8 corridor (the Scenic Byway). In western Rio Blanco County, sources of good quality sand and gravel are limited mostly to the river channels of the White River. The terrace deposits downstream from Rangely in the vicinity of County Roads 2 and 102 are largely exhausted and conflicts with local residents have increased. The only other significant reserves of sand and gravel near Rangely are on BLM lands or under BLM control.

Water Resources

The White River is the major source of water for domestic, industrial, and agricultural uses in Rio Blanco County. Peak flows in the White River occur during the months of May and June when runoff from melting snowpack is at a maximum. Occasional intense thunderstorms may temporarily increase flow in the White River during summer, but runoff contributions to the annual streamflow of the White River directly from rainfall generally are small. Snowmelt contains relatively small quantities of suspended sediment and dissolved solids. Thus, the large streamflow that originates from the North Fork and South Fork during spring and early summer transports large quantities of excellent quality water to the central and western parts of the basin.

The White River alluvial aquifer is another source of good quality water. The shallow stream-valley aquifer consists of buried and exposed river channel deposits of sand and gravel saturated with river water. The aquifer was formed as the White River meandered across the valley over geologic time. The White River aquifer ranges in width from 0.1 mile in narrow canyons to 1.5 miles in Agency Park and Powell Park. Saturated thickness of the aquifer is thinnest in western Rio Blanco County and averages about 22 feet. Deposits are thickest in Agency Park where saturated thickness is as great as 140 feet in several locations.

Agency Park has the greatest potential as a ground-water reservoir of any segment of the White River. Other segments of the aquifer having significant potential for good quality water supplies include the

Buford area, the Stillwater Valley along the South Fork, and the potholes reach of the North Fork. Generally, streamflow of the White River and the groundwater within the aquifer intermix. During times of runoff, the river recharges the aquifer and during low flow conditions the aquifer discharges to the river. As a result, the aquifer may be easily contaminated by surface water and/or surface activities.

Water storage in Rio Blanco County is both natural and man-made. Natural storage is mostly as groundwater within valley fill and bed rock aquifers. Surface water storage occurs in the high-elevation natural lakes in eastern Rio Blanco County and in the man-made reservoirs of Lake Avery, Kenney Reservoir, and several smaller impoundments. Several additional improvements in water management have been proposed or studied for the White River basin. The Yellow Jacket and Rio Blanco Water Conservation Districts manage large quantities of streamflow in Rio Blanco County.

Historically, water use and diversion within the White River basin has been for agricultural and domestic needs. Constraints on water use generally were limited to periods of drought. However, during the national energy crisis in the 1970's and early 1980's, projected water needs to support proposed oil-shale projects in the semiarid Piceance Creek Basin caused an increase in filings for water diversions. The potential loss of water from the White River for nahcolite mining and oil shale development and the increases in demand in the Lower Colorado River basin, prompted concerns that the White River could become an over-allocated river and that water shortages would be common.

The Town of Rangely obtains its drinking water directly from the White River, and the Town of Meeker obtains its drinking water supply from wells located in the valley fill aquifer in Agency Park. The protection of this water supply is a principal concern of the Master Plan and a major consideration in review of all future development proposals.

The State of Colorado, in cooperation with the Town of Meeker, designated a wellhead protection area for the town's water wells in 1995. The purpose of this designation is to identify those areas adjacent to, and most likely to, impact the town's wells. The town's wells are located in Agency Park in the vicinity of County Road 4 and the White River (fig. 8). The wellhead protection area extends roughly 2 mile on each side of the river for approximately 2.5 miles upstream from the wells to where the valley narrows. The wellhead protection area is designed mainly to protect the town's wells from possible negative impacts of adjacent surface activities. However, any significant changes or negative impacts to the water quality of the Meeker wellfield most likely would result from changes that occur in the White River, especially during low stream discharge conditions.

The degradation of the water quality of the White River or its alluvial aquifer would be expected to have serious consequences to residents of the county. For example, water treatment costs to the Towns of Meeker and Rangely could substantially increase. Water in private wells along the valley could become increasingly contaminated and require treatment. The diverse aquatic life in the river could diminish, resulting in decreases in fish populations and associated decreases in tourism and recreation. If severe degradation occurs, public health problems caused by water-born pathogens might develop. All of these impacts would tend to reduce the quality of life presently enjoyed in Rio Blanco County.

Water Sources, Treatment and Supply

The availability of potable water is a major consideration in most development. Good quality drinking water is limited to specific areas within the county. The White River and its associated alluvial groundwater are a major source of drinking water. The Towns of Meeker and Rangely, and the majority of domestic wells within the county, obtain water from this water system. Other significant sources of potable water include the shallow groundwater aquifers in the Piceance Basin, small stream valleys, and the numerous streams, lakes, and springs in high elevations, mostly in the eastern parts of the county.

Areas not adjacent to the major drainages are much less likely to have potable water, especially in the western parts of the county.

If the present rate of residential development along the White River continues, the impacts from this growth may seriously degrade the main source of water in the county. The private sewage disposal systems that are a part of rural residential development are a common source of nitrogen and phosphorous. Discharge from these systems can cause a serious degradation of water quality, stimulate nuisance algae growths, and increase health risks.

Wastewater

Sewage disposal in Rio Blanco County generally is by public sewage systems or by private sewage systems (septic tank and leach field). At present, only two public systems (Meeker and Rangely) are functioning within the county. In addition, a private sewage lagoon system, approximately 2 miles west of Meeker, serves the Stagecoach Park Campground.

Irrigated lands and floodplains generally have several characteristics which make them undesirable for conventional leach fields. These areas are subject to changes in groundwater levels during the spring runoff and/or times of irrigation. To function properly and meet minimum local and state standards, a conventional leach field that is buried 3 to 4 feet below the surface must have a minimum of 4 feet of unsaturated soil below the distribution pipe when groundwater levels are closest to the land surface. Much of the land adjacent to the major drainages, especially the White River, consist of gravel deposits. Typically, river water and the groundwater within the gravels and sands intermix freely. Alternating recharge and discharge of groundwater occurs during times of runoff and low flow conditions. As a result, the potential for groundwater and surface water contamination from leach fields is considerable. In addition, gravels do not meet perc standards and generally are considered an unsatisfactory soil for a leach field.

Leach field problems have been addressed by engineered systems with partial success. Sand mound systems have been used to address the problem of near surface groundwater. These systems tend to be expensive (2-3 times a conventional leach field) and sand mounds have both greater maintenance and failure rates than conventional systems. Soils which perc too fast (gravels) generally are modified by lining the trench or bed of the leach field with several feet of suitable soil. Although this design meets minimum state requirements, the effectiveness of the system to treat sewage is sometimes marginal. Providing 2 to 4 feet of filtration is much less efficient when compared with 10 to 20 feet or more filtration in areas having suitable soils. When high groundwater levels and gravelly soils are combined, as is characteristic of the White River Valley, the potential for the degradation of surface and groundwater resources increases. Nutrients leaching from these systems commonly stimulate significant growths of algae that, if severe, can reduce the availability of oxygen for fish and other aquatic life.

Small community sewage systems and package plants are an alternative to individual sewage disposal systems. These systems are used where poor soils, near-surface groundwater levels, or population densities preclude septic tank and leach field systems. The Colorado Department of Health (CDOH) generally promotes a non-proliferation policy regarding these systems due to their poor track record. Too often, these systems are poorly maintained and are subject to chemical loading shocks and poor performance in winter. These conditions can result in the discharge of untreated sewage directly into waterways.

Holding tanks have been used on a small scale to serve residences in areas unsuitable for leach fields. These facilities require frequent and expensive pumping. Holding tanks generally have proven unsatisfactory. The required constant pumping and associated expense have encouraged the illegal discharging of effluent to rivers, creeks, or gulches. Serious threats to public health can result from these practices. In the past, Rio Blanco County has allowed holding tanks for small cabins that originally were used for several weeks each year. In many cases, however, these cabins became year-round residences.

Transportation

Rio Blanco County has an extensive road network of state highways, county roads, USFS and BLM roads, and private roads. State Highways 13, 64, and 139 provide the major transportation corridors for most of the county. In addition, four county roads are classified as major collectors; they support and compliment the state highway system.

Rio Blanco County currently has jurisdiction over 138 roads totaling about 920 miles. Of the county maintained roads, 171 miles are paved, 264 miles are high use gravel, and 485 miles are unimproved. The county also maintains 65 bridges, 28 of which are structures greater than 20 feet in length. In winter, Rio Blanco County maintains about 365 miles of road. All streets and highways in the county are grouped into classes or systems according to the character of service. The Functional Classification System groups for rural streets/roads are listed below.

- Arterial: A primary service highway providing movement of traffic between major population areas.
- Major Collector: Road systems that provide access from major land use areas to arterials. Major collectors usually are 2 lanes and can accommodate from 500 to 2,000 vehicles daily. The right-of-way width for these roads must be at least 60 feet.
- Minor Collector: Roads that provide access to higher volume roads from farm and ranch lands or provide internal movement within residential areas. Minor collectors are two lane roads that serve local, low volume traffic, generally less than 500 vehicles daily.
- Local: Roads that provide access to and between minor collectors. Local roads are 2 lanes within residential, ranch, or public lands.

Four county roads totaling almost 138 miles are Major Collectors: They are County Roads #1 (Blue Mountain), #5 (Piceance Creek), #7 (Strawberry), and #8 (North Fork). In addition, 26 county roads totaling 182 miles are classified as Minor Collector roads. The remaining 600 miles of road are considered local.

A Snow Plan Guideline for winter maintenance was established by the Road and Bridge Department to ensure the maximum safety of the public and county snow removal personnel. County roads are categorized as Primary, Secondary, and Local roads.

- Primary Roads: Roads that serve as the main arteries to the towns and state highway system. Primary roads receive the highest level of maintenance.
- Secondary Roads: Roads that serve as collectors for the primary roads. Secondary roads will be maintained after snow removal is completed on the primary roads.
- Local Roads: Roads that have the lowest snow removal priority. Local roads will be maintained only after snow removal on primary and secondary roads is completed.
- No Winter Maintenance : It is not feasible or necessary to keep certain county roads open during the winter months. These roads are generally posted with "No Winter Maintenance" signs after the last regularly scheduled hunting season, on or about mid November. No winter maintenance roads will be reopened in the spring depending on location, classification, and weather conditions. Rio Blanco County goals are to open all county roads by mid-to-late May. Developers and

property buyers should note that Rio Blanco County has no obligation to provide winter maintenance on designated "No Winter Maintenance" roads.

- Blizzard Conditions: When snow and wind cause low visibility that jeopardizes the safety of snow removal personnel, road maintenance will be delayed until safer conditions exist.
- Emergencies: In emergencies determined by the Board of County Commissioners or the County Sheriffs Office, the Road and Bridge Department will make every reasonable effort to provide access to the involved area.

No major expansions for the county road system presently are planned. Maintenance and selected improvements will occur as necessary. Future additions to the system will occur, however, in support of new residential and industrial projects.

Airports

There are two public general-aviation airports in Rio Blanco County. The Meeker Airport is contained mostly within the Town of Meeker in eastern Rio Blanco County. Similarly, the Rangely Airport is within the Town of Rangely in western Rio Blanco County. Both facilities are owned by the county. The airports are used by recreational and student pilots, federal agencies, medical flight operations, aerial spray operators, air taxi operators, and business and tourism industries. Aircraft vary from small single-engine aircraft to business jets and helicopters. Airport managers anticipate only moderate growth over the next 20 years.

The proximity of the county airports to the Towns of Meeker and Rangely is convenient and economical. However, this proximity also raises several land use conflicts with urban development near the airports. The Federal Aviation Administration (FAA) requires that areas adjacent to airport properties be considered for LDN noise contours, runway protection zones, airport influence zones and areas, and FAR Part 77 airspace. Meeting these regulations will require cooperation and coordination between the county and the towns. Regulations on zoning, development, and land use activities will be required to ensure that the airports meet FAA guidelines. Much of the airport maintenance and improvement costs are provided through FAA grants. Meeting FAA requirements is necessary to receive continued funding for operation and maintenance of the airports.

Although parts of the Meeker Airport are adjacent to unincorporated lands in Rio Blanco County, the airport is surrounded mostly by the Town of Meeker. Access to the airport is by County Road 81 from State Highway 13 east of Meeker. The original airport property (approximately 214 acres) was purchased in the 1930's by the Town of Meeker for general aviation services. In 1959, Rio Blanco County assumed ownership of the airport. During the 1980's and 1990's several land acquisitions and runway improvements were completed to accommodate larger aircraft.

The Meeker Airport has an airport reference code (ARC) of B-11. The airport has one runway and a building area near the west end of the airport. The building area contains the FBO office, airport manager residence, and numerous hangers. Proposals to extend the runway to a maximum length of 8,100 ft. and a width of 75 ft. to safely accommodate larger types of aircraft are under consideration.

The Rangely Airport is approximately 2 miles east of downtown Rangely; access is through an entrance road from State Highway 64. The airport ARC is B-11 and the airport covers approximately 327 acres. Although open to public use, the facility is used extensively by Colorado Northwestern Community College (CNCC) for pilot training and aircraft courses.

Rangely Airport has two runways, a taxiway, and an aircraft apron. Runway designated as 6/24 is constructed of asphalt and has a length of 6,700 ft. and a width of 75 ft. The airport has an administrative building that houses offices for the CNCC personnel and the airport manager, a trailer house for the manager, several hangers including a maintenance hanger for the college, and associated accessory structures.

Electricity

Electricity in Rio Blanco County is supplied one of two cooperatives, White River Electric or Moon Lake Electric. White River serves the eastern end of the County and Moon Lake the western end.

White River Electric Association was incorporated in 1945. Power for the association is supplied by Tri-state Generation & Transmission Association Inc. The total number of employees is 20 with a payroll of $1,091,654. Total property taxes paid in 2001 were $110,309,15 with total revenue sales of $7,988,664 on sale of 138,242,694 kilo watt hours. The association serves eastern Rio Blanco, southern Moffat, and northern Garfield County's.

Moon Lake Electric was organized in 1938 as a rural electric cooperative by residents of Northeastern Utah who were unable to obtain electric service from a private power company. S.K. Daniels, an early pioneer of Moon Lake Electric, wrote a letter to the Rural Electrification Administration in Washington, inquiring about possible loan funds to enable residents to begin construction of lines and equipment. Soon a non-profit corporation was formed and funds were approved, allowing residents to get started with building their own power system. At the present time, Moon Lake employs 83 full-time employees and furnishes power to over 14,000 member accounts in Northeastern Utah and Western Colorado. Moon Lake's headquarters office is located in Roosevelt, Utah, with district offices in Altamont, and Duchesne, Utah. Rangely Colorado is the home of our Colorado District office.

Plan Sustainability-Strategic Management and Coordination

The following description is partly taken from the county's emergency/disaster strategic management program statement. The concepts and processes described are universally followed in all Development Department programs and are the basis of the county's comprehensive integrated emergency/disaster management approach. This outline serves to describe this program and the assumptions used in making policy, and establishing objectives and goals. The format is not stand-alone and the concepts of management described in this document are the same as the ones used in land use, natural resources and environmental health.

How a government designs its processes for administering its programs can have a profound impact on effectiveness and the community. Even more important are the assumptions that underpin the policies on which the processes are based. This section introduces the policy assumptions and concepts that the county has used in designing and follows in administering its integrated emergency/disaster, land use, natural resource, and environmental health management programs.

Management Methodology

An assumption that is often overlooked by decision makers is the effect policies can have on how agencies view the world around them. Some agencies see the world in a very narrow manner. Some see it as they are prescribed without consideration of any broader implications, and some do not see it at all. One of the major purposes behind a comprehensive plan and/or program is to define how policy will be set based on how the world is to be viewed. This world view is fundamental to how policies are set. Rio Blanco County's approach is built on an adaptive systems view of reality. This means defining our view in a very broad way based on an understanding of complex systems while administering the program to flexibly apply policy, adapt to changing circumstances, and manage the common issues between land use, natural resources, environmental health and disaster management in an integrated manner.

Adaptive systems' thinking refers to the combining of two different organizational perspectives based on certain assumptions about the world. The first perspective is system's thinking, which is a way of picturing the world based on understanding the behavior of the parts and how they act together in order to understand the form and behavior of the whole[1]. At the core of systems thinking is the science of complex systems and systems management[2]. The second perspective is adaptive management which refers to an organizational process that implements an activity, monitors the effect, learns from the result and adjusts policy to shape a more positive outcome[3]. Adaptive systems management is an organizational approach that has been developed from the blending of these two perspectives.

Sometimes the use of these terms is confusing because there are many different types of systems, and often systems within systems. The idea of an administrative process as a management system can be confused with the idea of the county as a complex system. However, from an adaptive systems perspective both activities can be approached using the same conceptual model. All systems exist in various states, have differing internal processes, and react in different ways to different inputs. Whether administering a program or determining the appropriateness of a development proposal a similar set of principles can be applied and these principles stem from an understanding of the nature of complex systems.

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[1] For a more complete discussion reference complex systems, nonlinearity, chaos theory, etc.

[2] See: Dynamics of Complex Systems, Bar-Yam (1997), The Leaders Handbook, Scholtes (1998), Ackoff (Goal-QPC 2001).

[3] See: Compass and Gyroscope by Kai N. Lee (1993)

Managing a comprehensive program that integrates land use, natural resources, environmental health and disaster management may seem like a daunting task however if properly structured around basic system principles it can simplify processes and resolve issues resulting from a narrower view of the world. It can allow for the more efficient use of limited resources and help people focus on issues of real concern. From an adaptive systems perspective management in this manner is about focusing on maintaining the pattern of the system(s) while understanding its natural tendency to change and acknowledging the need to not allow unreasonable variability. From a policy perspective this implies that emergency management be considered at every step within the development process and that activities be carried out to eliminate and at least reduce foreseeable problems. Thus this management system and the other integrated disciplines are built around the key principles of understanding the complex system, adaptively changing processes based on honest appraisals of what is going on, and not allowing reasonably foreseeable risks to hurt the community when other options are available.

Hazard and Risk

The world is an inherently hazardous place. All kinds of hazards exist that can manifest to result in many different unfortunate situations. Natural hazards include fire, flood, and earthquake and, as our forebears knew, a host of hungry creatures. To some extent the purpose of civilization is provide a framework to cope with hazards. This task requires that programs be administered so that individual and community values are protected from those hazards that can be reasonably, justly, and cost effectively eliminated and/or reduced. Risk is a concept used to identify, measure, and categorize which elements of an organization (community, business, agency, etc.) are threatened. In its simplest form risk is the measure of threat a hazard poses to something. Risk provides a basic linking principle on which a management system can be built.

Understanding hazards helps point to where threats to buildings, structures, communities and/or complex systems exist. Determining the potential threat of a hazard indicates the level of risk. Balancing the level of risk with other priorities such as the cost to eliminate and/or reduce the risk provides a basis for decision-making. This is the reason risk can be used as a key linking principle in managing variability in a complex system.

Implementation of Risk

Risk as a concept, and the associated activities of risk characterization, analysis, assessment and management, provide the linking principle to measure when to act. The comprehensive emergency/disaster management program uses risk as a key concept for focusing on what should be of concern. Incorporating risk in the process follows conceptual guidance as outlined by the National Research Council and involves several interrelated steps. Two of the most important are risk characterization and risk management. Risk characterization is defined as:

> a synthesis and summary of information about a potentially hazardous situation that addresses the needs and interests of decision makers and of interested and affected parties. Risk Characterization is a prelude to decision making and depends on an iterative, analytic-deliberative process.

Risk management is defined in terms of making decisions from the information generated in risk characterization. This establishes risk management as the broad policy framework for managing risk after hazards have been identified through analysis of the situation(s) and values weighted. Thus management of emergency and disaster risks follows a similar outline as that used in industry as described in the following steps: (1) identifying exposures to accidental loss that may interfere with an organizations basic objective; (2) examining feasible alternative risk management techniques for dealing with these exposures; (3) selecting the apparently best risk management technique(s); (4) implementing the chosen risk management technique(s); and (5) monitoring the results of the chosen technique(s) to ensure that the risk management program remains effective. (Head, Horn 1991).

Risk management is implemented in a programmatic manner after risk characterization. In order to characterize risk, hazard information has to be compiled into a reference mechanism (hazard maps). Datasets and models are used to produce an actual hazard index and determine the extent of the threat of the hazard to identified values. The hazards are imposed over the features of the community represented in datasets, graphic images and maps that are integrated through a Geographic Information System (GIS) and analyzed to expose vulnerability. This information provides risk analysis data. From risk analysis a risk management policy framework for mitigation, reducing vulnerabilities, and preparing for hazard events can be developed.

Risk Reduction and Mitigating Hazards

After the job of identifying risk is complete the task of defining priority activities for mitigating hazards can begin. The priorities are organized and discussed with decision-makers and stakeholders. Based on available resources, decision-maker concerns, and stakeholder input, priorities are organized into relevant programs, plans, projects and preparations as applicable. The risks to be addressed are indicated for the differing types of exposure. Exposures can be managed in a number of different ways and include mitigation, preparation, and exercise. Priority lists are designed to indicate the nature, extent, and activity that is necessary for managing the risk. This is the stage at which it is critical that all the stakeholders and communities work together to determine priorities, considering as many different perspectives as possible.

Once priorities are established, resources can be sought and assigned to complete the projects outlined. These activities are usually implemented through action and/or project plans. Because of the diversity of tasks and hazards (wildfire, flooding, etc.) many different action plans will be developed. Often activities of lower priority will be accomplished before those of higher priority because they are simply easier to accomplish. Thus multiple projects will be in various stages and/or phases of implementation at any given time.

Coordination and Stakeholder Involvement

One of the keys to a successful emergency/disaster management effort is the ability to organize the program so activities are supported by all relevant stakeholders. This requires identifying how to develop an organizational structure that will facilitate cooperation and involvement. Both a good cross-section of stakeholders and coordinating them within a reasonable resource base are necessary. Too many groups not working in unison will lead to a chaotic situation involving such issues as territory and communications. In small communities this also leads to burnout as redundancy of committee's drains volunteers. To overcome these issues the county has organized a local emergency planning council (EPC). This council has been formed out of the Emergency Medical Service Council (EMS). The EMS council is a state mandated group that meets monthly. Members of the group include most of the relevant stakeholders involved emergency/disaster management. The layout and structure for the EPC is described on the following diagram (Diagram 1):

Emergency Planning Council (EPC)

(Made up out of the EMS Council)

- RBC
  - Commissioner
  - Sheriff
  - Emergency Manager
  - Health Nurse
  - Planning
- Meeker and Rangely
  - Police
- Rangely and Rio Blanco Fire
  - Fire Chiefs
  - EMS
- West/East Hospitals

Subcommittees (PODs)

- Emergency Medical
- Communications
- Natural Hazards
  - Watershed/Flood
  - Wildfire
- Emerging Issues
  - Terrorism/etc.

Stakeholders

- Districts
- Municipalities
- Schools
- Health Care
- Business
- Industry
- Agriculture
- Agencies
- Others

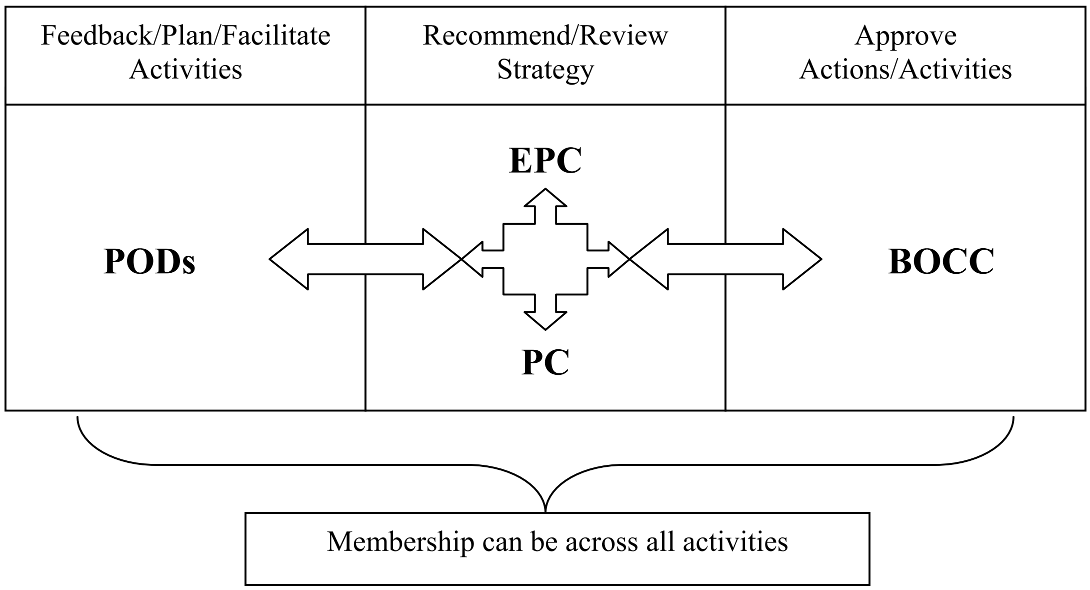
The state mandated Emergency Medical Services Council is the template on which the Emergency Planning Council is built. A limited number of EPC members work with other relevant stakeholders on specific subcommittees (PODs) to tackle specific issues. The work of these subcommittees is brought back to the EPC so there work can be put into practice.

Diagram 1: Emergency Planning Council Structure

Through the EPC a series of programs are coordinated. The detailed work on these programs is carried out by subcommittees referred to as PODs. The PODs consist of an expanded number of stakeholders who have an interest in specific issues. For example the wildfire POD includes ranchers and federal firefighters who are otherwise not involved with issues such as emergency medical response. This format has proved a successful way for coordinating the diverse groups involved in these subjects.

Part of the benefit achieved from forming this group has been the ability to discuss and assign responsibilities for carrying out specific activities. Workloads can be discussed and assigned to those who have a direct involvement. Those who do not are still informed as the POD groups funnel the work back through the EPC. This maintains cohesion and involvement without recourse to long tiresome meetings for the group as a whole. Further the EPC is a counterpart to the Land Use Planning Commission (PC) and members of the PC are on several of the PODs. This means that decisions made regarding land use consider mitigation and emergency/disaster issues. These group relationships and responsibilities are outlined on the following two diagrams (Diagram 2 and 3):

Diagram 2: Relationship of Various Coordination and Decision-Making Groups



Definitions:

- PODs are sub-committees made of individual stakeholders that are specifically involved in the topic defined I.E. water/flood, land development, wildland fire, emergency medical, etc.
- EPC is the Emergency (Disaster) Planning Commission. This group has been formed out the State mandated Emergency Medical Services (EMS) Council. It still fulfills those EMS goals.
- PC is the Land Use Planning Commission.
- BOCC is the Board of County Commissioners.

Diagram 3: Basic Emergency/Disaster Management Responsibilities

Objective	Responsibility	Associated	County Lead
Characterization	DP	BLM/FS, EM, MC	DP
Mitigation	DP, BLM/FS	CC, EM, MC	DP
Preparedness	EM, SP, FMS	BLM/FS, CC, PH, MC, HS	EM
Response	SP, FMS, HS, BLM/FS	CC, PH, MC, HS	SP
Recovery	EM, CC	BLM/FS, SP, DP, MC, PH	EM

Basic Local Agency Responsibilities

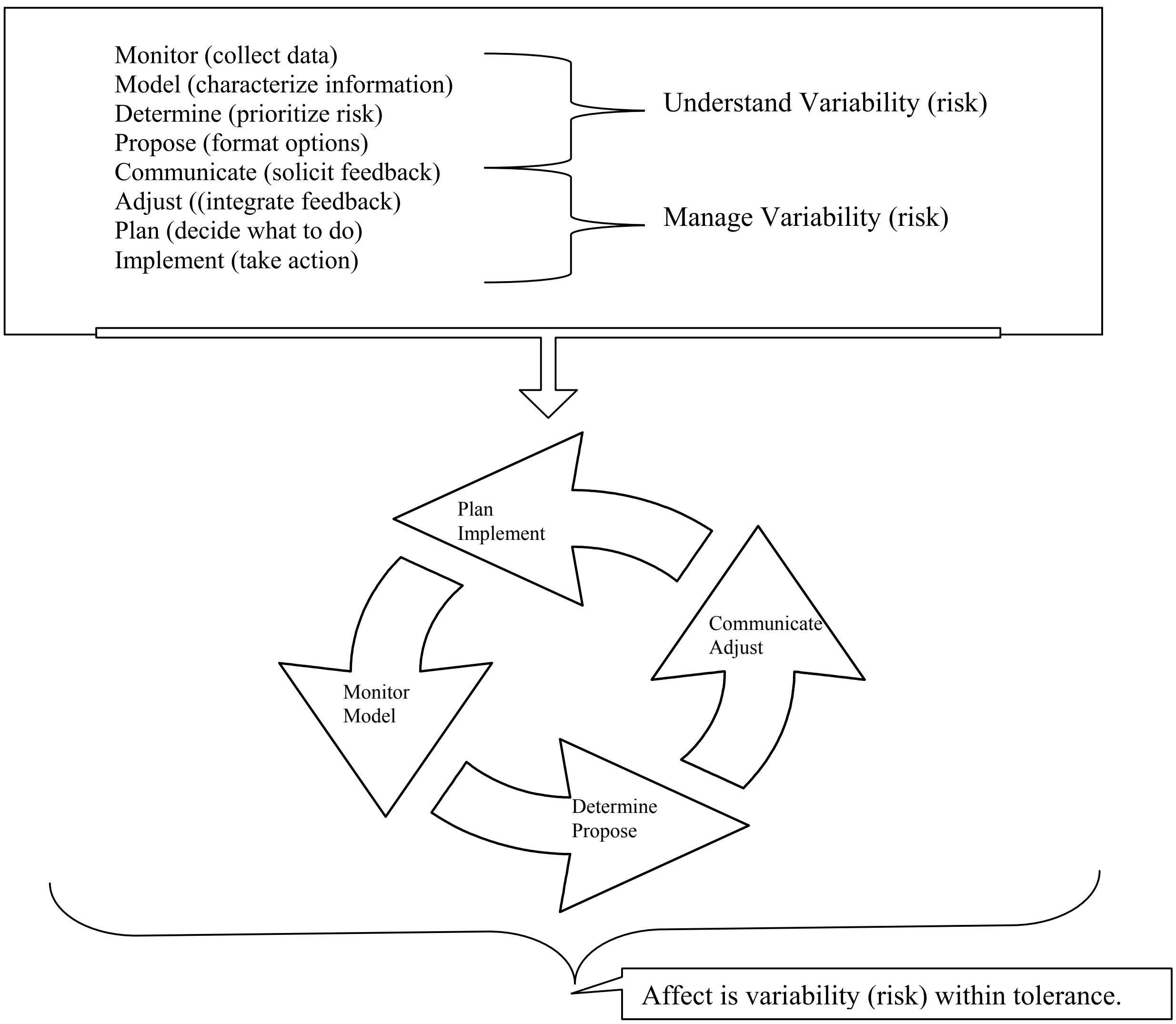
Legend:

- County Commissioner = CC
- Law = SP
- Emergency Management = EM
- Disaster Planning = DP
- Public Health = PH
- Municipalities = MC
- Local Federal Agencies = BLM/FS
- Fire/Emergency Medical = FMS
- Hospitals = HS

Information Flow and Maintenance

The work carried out by the EPC, PC, and PODs results in a set of activities for addressing hazards and/or improving the program. The activities include work on response plans and procedures, call lists, exercises, mitigation projects and a multitude of other details that must be attended to in order to achieve the various objectives within the sphere of the five key emergency/disaster management areas. Much of this work falls onto the shoulders of the responsible county leads. Additionally the information generated has to be disseminated outside to the public. All POD meetings are by nature public meetings as are EPC and PC meetings however county staff has to ensure the information developed reflects the input from involved stakeholders. Diagram 4 exemplifies how the process flows and how this cyclical approach is part of a feedback loop that incorporates the key principles of understanding complex systems, adaptive management, and prioritizing based on risk.

Diagram 4



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Program Sustainability

Through use of the key principles and this management approach the program should have consistency over the longer term. The cyclical nature of the approach provides a process for maintaining and improving the program. This instills a respect for program evolution and builds a culture of improvement while acknowledging the indefinite nature of emergency/disaster management. It also builds on successes even as it adjusts for failure while keeping an eye toward achieving sustainability.

List of Involved Stakeholders

RBC

- County Commissioners
- Development
- Sheriff and Emergency Management
- Road and Bridge
- Planning Commission

Town of Rangely

- Town Council
- Administration
- Police

Town of Meeker

- Town Council
- Administration
- Planning
- Police

Federal Bureau of Land Management (local office)
United States Forest Service (local office)
Rio Blanco Water Conservation District
RBC Fire Protection District (Emergency Response Services)
Rangely Fire Protection District (Emergency Response Services)
Natural Resource Conservation Service (local office)
United States Geological Survey (local office)

Assorted private stakeholders including

- Chuck Whitman
- Bob Tobin

Adoption

Once this plan was developed following the process as outlined, the completed document was forwarded to the County Board of Commissioners for adoption. The adoption occurred at a formal public hearing. Notice of the hearing was published in the local paper. The county is actively seeking to implement the priorities outlined in the action plan. Each project will be implemented following the processes outlined in this document.

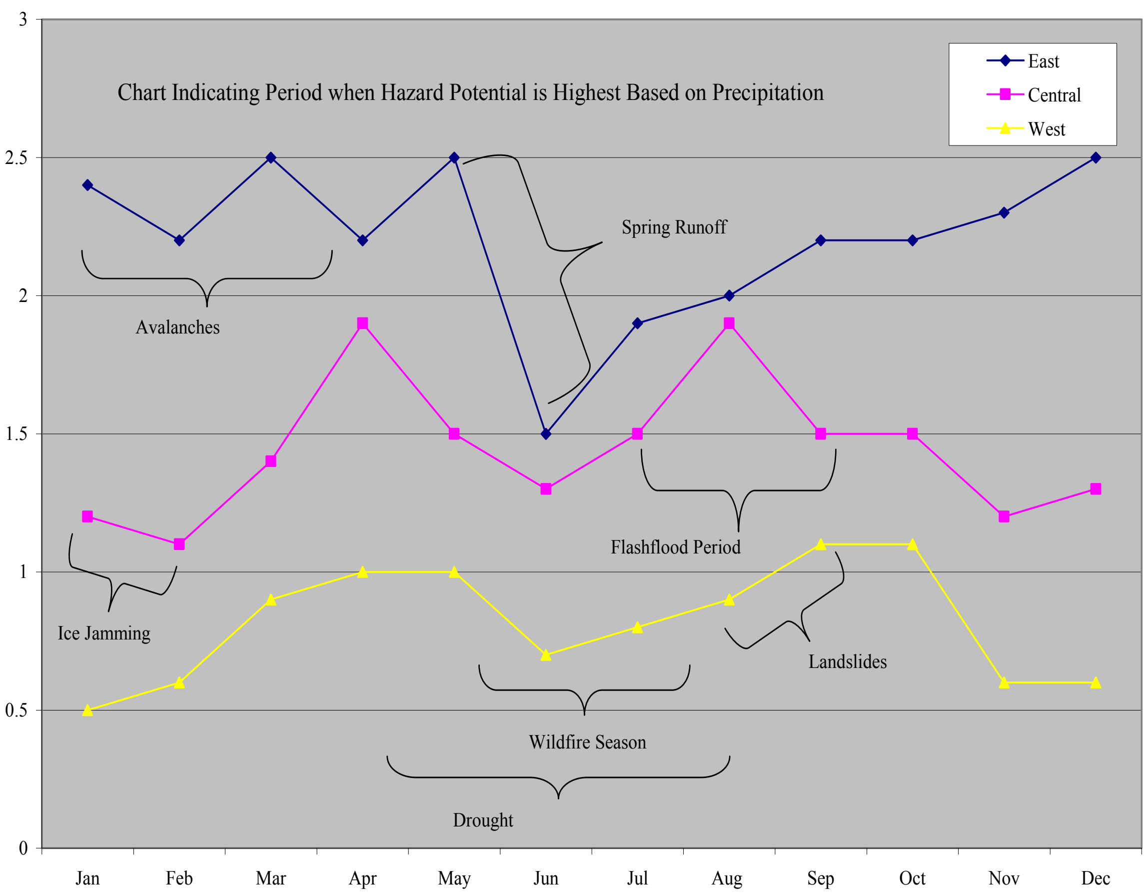
Part III

Approach

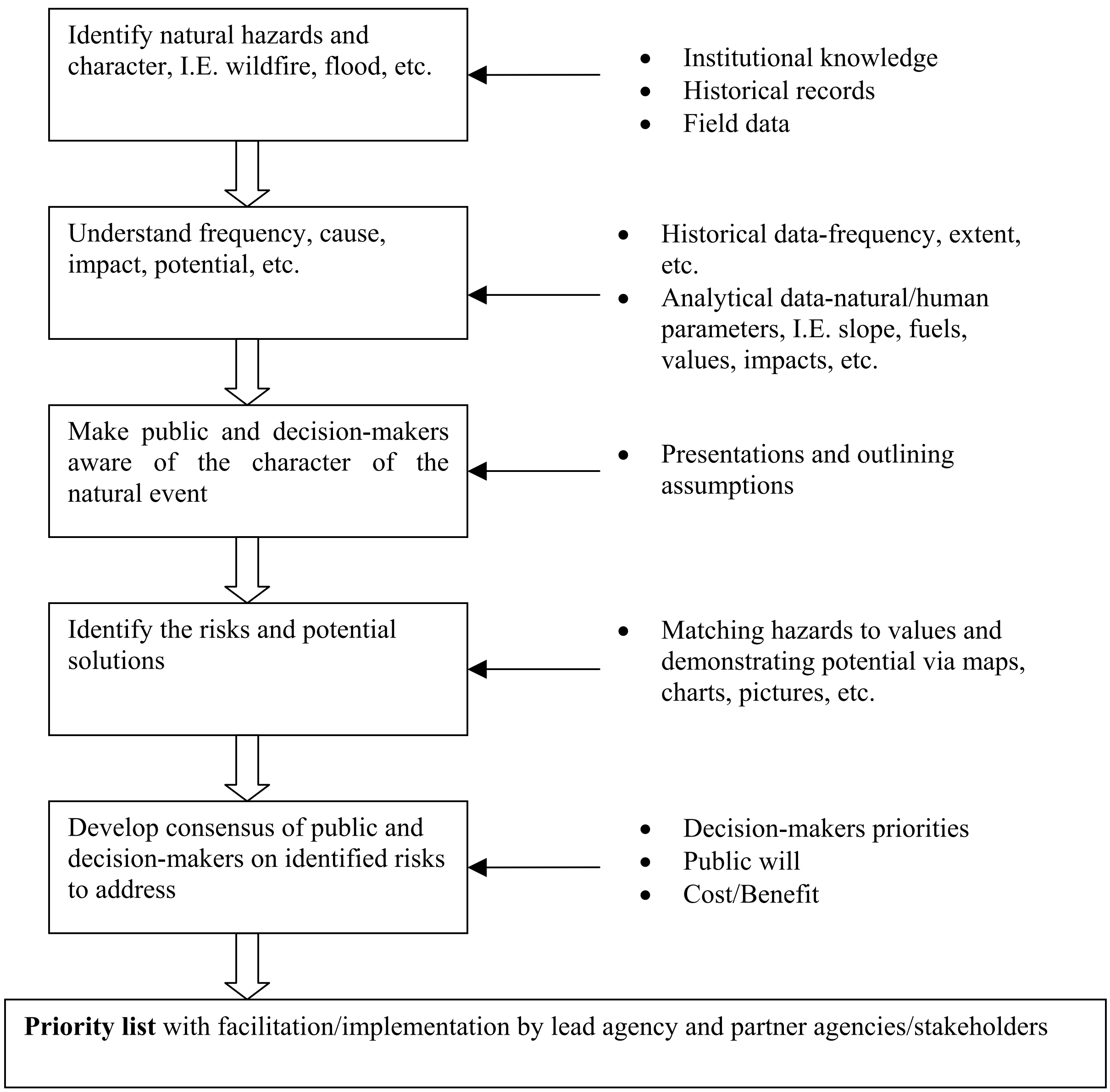
Hazards and Risks in RBC

In Rio Blanco County, and surrounding lands of a similar type, all major natural hazardous events are related to precipitation. Whether caused by a lack or excess of moisture the common linking feature is related to precipitation. Use of precipitation as an indicator of type and time of hazard provides an easy way to relate the various hazards and understand their interrelationships. For example in late summer when the monsoonal rains are produced through tropical flow from the southwest wildfires diminish if not altogether disappear, however, flash flooding with its associated debris flows and erosion become the predominate concern. The corresponding interrelationship is that the earlier fires of the summer enhance the affect of the rains and the potential intensity of flash flooding. The hydrological regime drives changes to the land and is a key ingredient in setting up the conditions for all sorts of geologically related natural hazard potentialities. A similar phenomenon exists for wildfire and avalanche. The extent and severity of the natural hazard is driven by the amount of moisture. On the chart below three distinct areas of Rio Blanco County are represented. These areas are the eastern, central and western regions. As can be noted from the left hand side of the chart each region follows a very specific moisture pattern and based on the amount received the following patterns correspond to the natural hazard events. Note: these hazard events occur across all regions however for demonstration purposes they are highlighted on the chart in the region where the phenomena is most pronounced on a year to year basis.

Average precipitation (*Y*) relationship to natural hazard types in Rio Blanco County



This understanding in part is revealed when a list of historical hazards and corresponding emergency events are analyzed. A series of analyses have been carried out using geographic information systems and historical data to construct hazard relationship models. These models provide information on the extent and location of the hazards based on the conditions of the area and known parameters. The models are built following conceptual practices and /or programs such as the Federal Emergency Managements Agencies HUZUS flood related model, Department of Agricultures wildfire FARSITE model, decision support models and internally designed models. The various methodologies are outlined in each section related to the hazard. Priorities for mitigation strategies in this plan are based on integrating local historical knowledge, public consensus, decision-maker priorities, professional judgment, historical data, cost/benefit, hazard, and risk analysis models. The focus is for implementation of priorities that are high risk after being selected using the following process test:



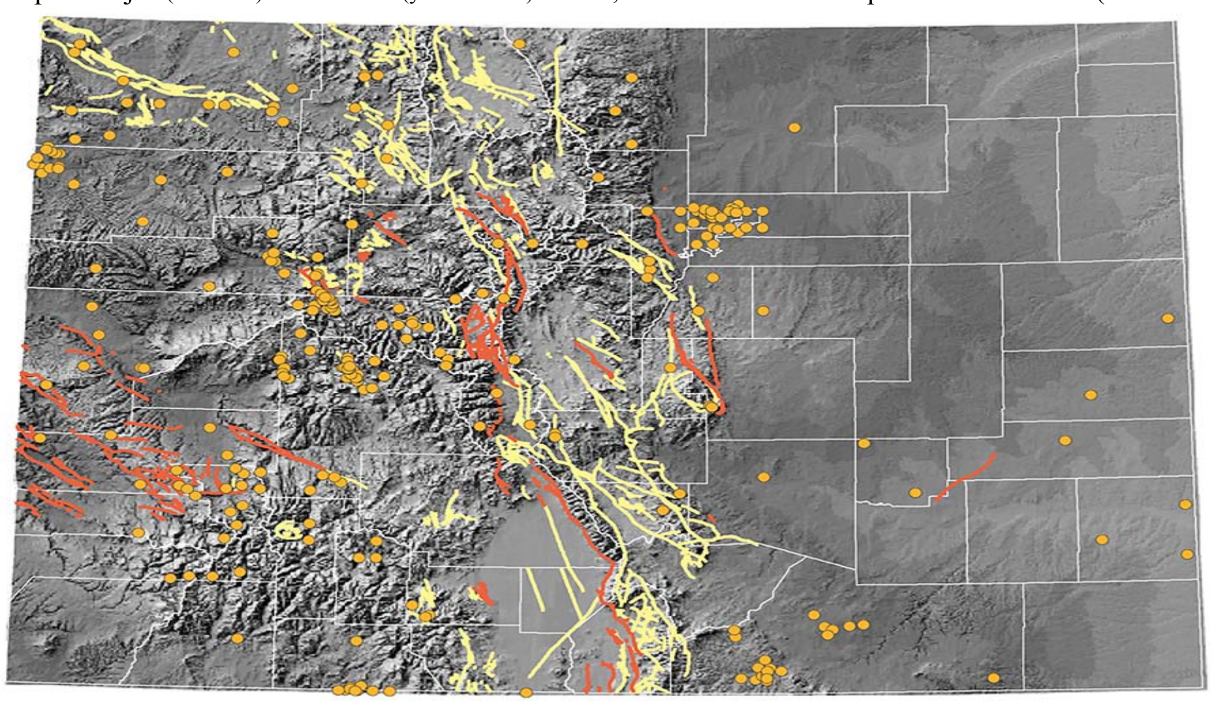
Key to understanding hazards is integration of data in a systematic format that properly weighs and values the data so that risk can be accurately portrayed. Accurate information requires consideration of all available data including social/institutional knowledge, historical records, field data, historical data, and analytical data. This data comes in both qualitative and quantitative form.

Mitigation and Methodology for Determining Hazard and Risk

In 1240 Henry de Bracton summed up the purpose of mitigation by stating "an once of prevention is worth a pound of cure". Unfortunately he did not go any further and explain how it can be accomplished. Preventing disasters by understanding and setting mitigation priorities can be a complex task. Many assorted details such as scale, level of detail, accuracy of records, availability and existence of data, have to be considered and methods have to be developed to organize and use information in order to prevent disaster. In this plan mitigation priorities have been derived from analysis of risk. Risk is characterized based on the extent and character of hazards and the vulnerability features of value have to those hazards. High risk is considered any situation and/or area where features of value have a considerable potential for loss if a hazard event manifests. A value is considered anything that would require replacement, and/or is irreplaceable and includes infrastructure, buildings, persons, habitat, endangered species, et cetera. Low risk is considered any situation and/or area where features of value have a small potential for loss from the hazard event. It should be noted that a situation or area can have a very high potential hazard and be low risk as no features of value are threatened. Hazard is determined based on the characteristics of the phenomena. For example the hazard of wildfire is driven almost exclusively by fuel type.

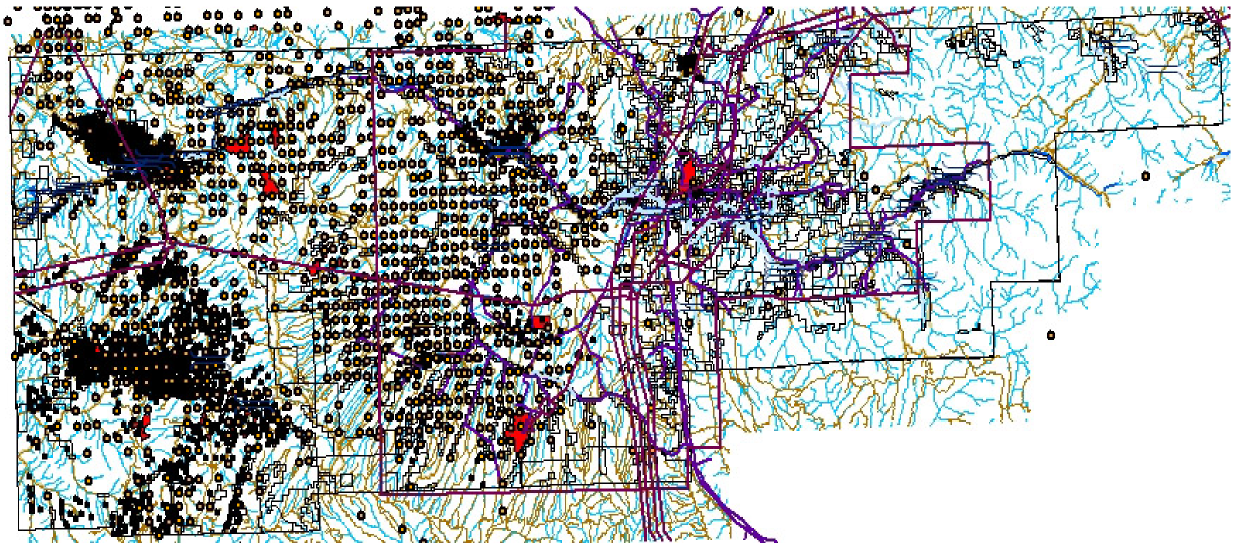
Four types of primary hazards have been identified and modeled for risk analysis in Rio Blanco County. These are flood, wildland fire, avalanche, and geologic stability (debris flows, shrink/swell, erosion, etc). Other natural events such as earthquakes, tornados, hurricanes, volcanoes, and associated hazards are not a threat as either no record exists of their threat or they are fundamentally not possible because of natural conditions. For example no major or minor faults are recorded for RBC and the recorded earthquakes are considered minor (Map 1)

Map 1: Major (red lines) and Minor (yellow lines) Faults, and Recorded Earthquakes in Colorado (CGS 2002)

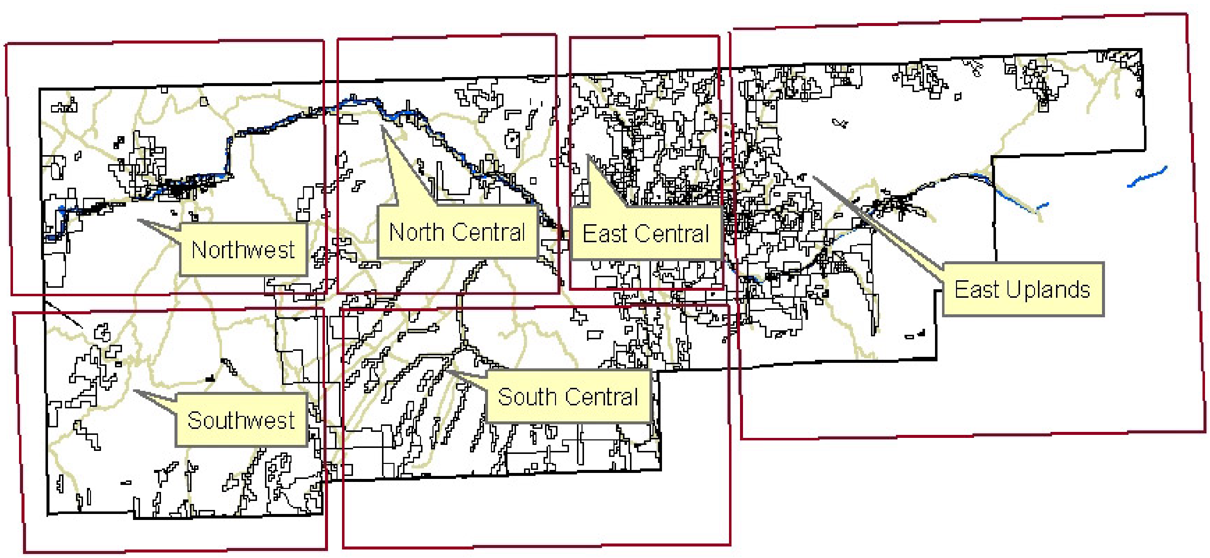


For the major hazard phenomena (flood, wildfire, avalanche, geologic stability) four models have been built. A description of the natural hazard and the methodologies and assumptions for each model are described in detail in specific sections of this plan. This data is used to identify risk. Each hazard can be ranked in significance based on historical occurrence. Historical occurrence is used as a component in both hazard and risk analysis. In hazard analysis it is used to determine significance and intensity (Map 2). In risk analysis it is used to determine past and potential impact. Primary information used in hazard analysis is data on the physical characteristics that are fundamental parts of the process that catalyze a hazard event. An example is the physical characteristic of fuel loads that must be present to create crown fires as a factor in severe wildfires.

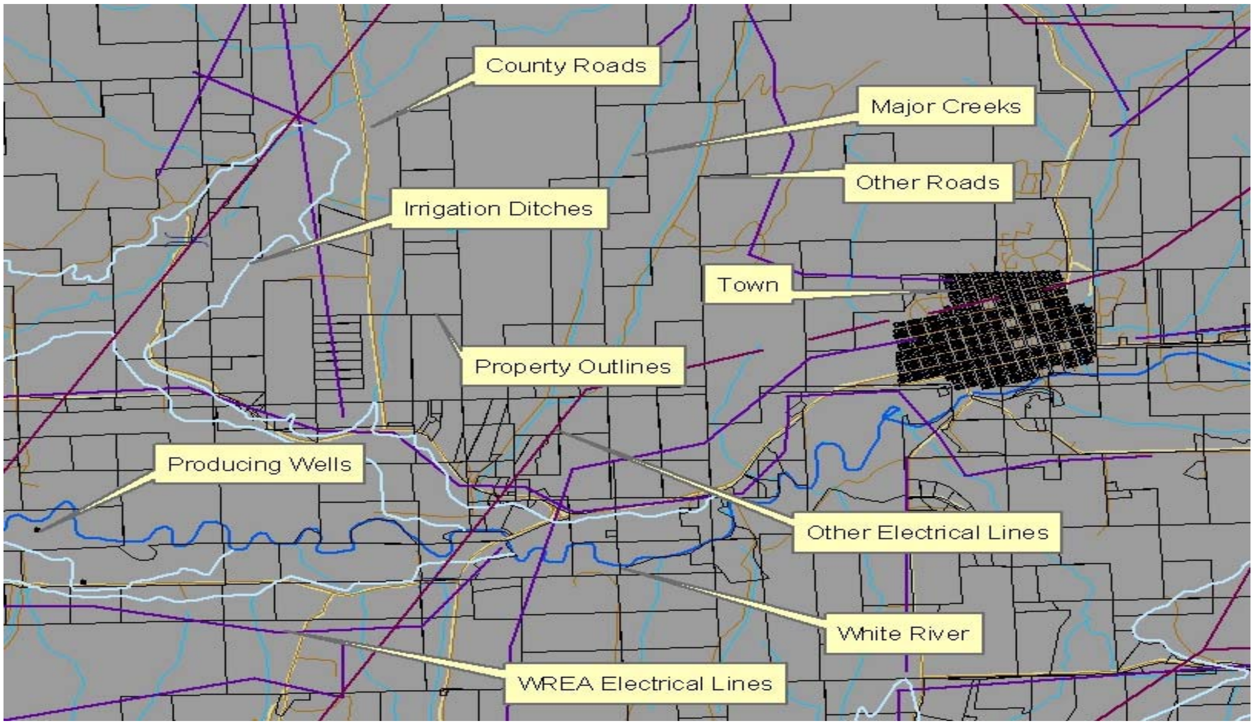
Map 2: Example of the Type of Historical Information Used with Hazard Maps - Ignitions from 1980 to 1998 and fire areas 1999 to 2001 for Rio Blanco County (BLM 2002) Imposed over Base Value Data including oil/gas wells.



In order to present this information RBC has been broken into six specific areas. These areas are called hazard regions. The hazards regions are as follows:



The hazard maps also include basic features (values) that are used in risk analysis. The basic value information displayed on the maps is as follows:



On all the hazard maps information is represented in a single format running from high hazard as red to low hazard as green. Areas of white represent data gaps. As with all models the information can be refined. Inaccuracies exist in many aspects. These are discussed in the more detailed sections of the plan. A note of caution needs to be made about these maps. These are products that are used in the process described above. They are part of providing good information so good decisions can be made; however they should never be used in isolation and have to be integrated with field, historical, economic and legal data. All hazard and risk analysis model information are only pieces of a larger puzzle. In the end all the information used has to be wisely integrated to reveal where potential mitigation is feasible. This human component is part of the analysis and planning process, and has to be carried out by individuals who have an understanding of the dynamic of the environment and fundamental nature of the natural hazards.

General Assessment of Vulnerability to Natural Hazards

All the data was used for the key identifying hazards in the county a matrix has been developed to cross reference vulnerability with values. Basic values were aligned in a column and ranked according to how critical the facility is in responding and maintaining community services. Levels are ranked as follows:

Critical Facilities	
Level I	Very critical need for community and regional service
Level II	Critical need for community and regional service
Level III	Medium critical need for community and regional service
Level IV	Low critical need for community and regional service

The level of hazard was ranked using information as described in this document on the following scale:

E = Extreme	
H = High	
M = Medium	
L = Low	
A = Almost None	

The criteria used in judging hazard included analysis from GIS, field data, historical knowledge (as described in this document and the qualitative parameters of possibility (likelihood of hazard manifestation), location (position in relationship to hazard), security (level or extent of protection), and continuity (ripple affect throughout).

Part IV

Methodologies

The following sections describe the natural events and outline the methodologies used to analyze hazards and risks to generate information for determining potential mitigation projects. These methodologies describe the assumptions followed in developing the models presented in this plan. Natural events that produce impacts have been grouped into three categories. These are:

1. hydrological related events;
2. meteorological and biomorphic related events;
3. and geological and geomorphic related events.

These groupings provide a basic way to relate the natural events. Often it is the interaction of events, as fundamental properties of the complex system that result in a natural event that produces a disaster. For example a devastating flash flood that produces a destructive debris flow as a result of an intense crown wildfire. It is the interaction of these forces within the system that produces the emergency. Even so for purposes of this plan the events have been clustered into primary categories. Flooding is a hydrological event; wildfire is a biomorphic and meteorological event, etc. As pointed out in Part III the natural hazards RBC faces are to a great extent driven by the relationship of these fundamental factors that are conditions of the hydrology, geology, meteorology and biology of the county.

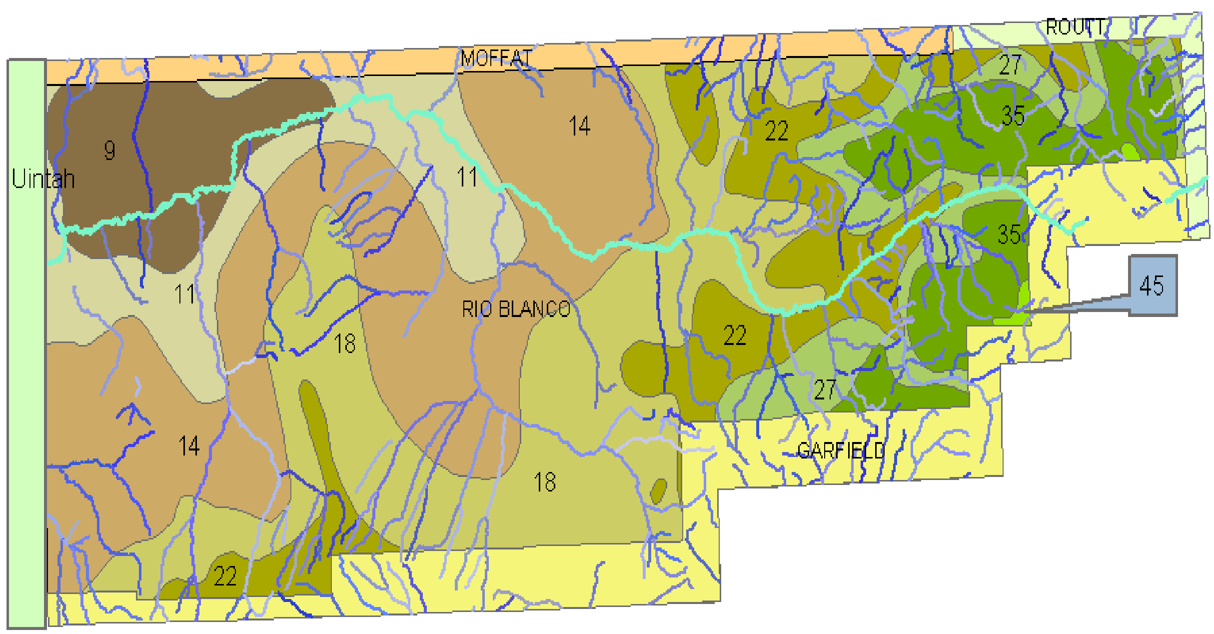
Hydrological Related Natural Hazard Events

Hydrological Setting

The White River is one of the principal rivers of northwestern Colorado and the main source of water in RBC. Most of the water in the river originates from snow pack (about 78 percent of the annual discharge) that accumulates in the high mountain elevations of the White River uplift in eastern Rio Blanco and Garfield Counties. The main-stem of the White River begins at the confluence of the North and South Forks near Buford. The watershed encompasses a complex set of perennial and intermittent stream systems characterized by a highly erosive and unstable landscape.

The White River flows from an alpine climate westward through transitional climates near Meeker into a semiarid climate in western RBC (Map 2). Tributary streams east of Meeker mostly flow throughout the year (perennial) or seasonally (intermittent). Except for Strawberry, Piceance, Yellow, and Douglas Creeks, tributary streams west of Meeker mostly flow in response to storm events or occasional snowmelt (ephemeral). The drainage area of the White River at the Colorado-Utah State line is 3,680 square miles and the annual discharge normally ranges between 400,000-700,000 acre-feet.

Map 2 (Numbers indicate average precipitation for areas of RBC. Light blue line is the White River, dark blue major creeks)



The channel of the White River above Meeker may be characterized as relatively steep with a shallow depth. In the five miles upstream from Meeker the channel slope varies considerably. Within Meeker the channel slope decreases in the area of the 5th St. Bridge and again downstream from the 10th St. Bridge. This flattening out of the river is also characterized by an increase in the size and frequency of meanders. Gravel bar formation is common on the reach through Meeker. The size and location of these bars varies over time. In the past dredging of the channel has been performed in connection with other projects, however erosion of the upstream banks has continued and deposition has reoccurred and the gravel bars have continually reformed.

As the river continues downstream of Meeker it continues to flatten out to slowly meander until it meets Kenney Reservoir. Here, at the mouth of the reservoir the considerable sediment loads normal in this reach of the river are dropped out. Below the reservoir, through the town of Rangely, the river is slow and characteristic of a channel moving through a thick alluvial plain of sediment deposition of highly erosive soils.

Groundwater in RBC is mostly contained in bedrock aquifers in the strata of the Mesa Verde formation (Cretaceous Period) and in the fractured rocks of the Green River and Uinta formations (Tertiary Period). Additional groundwater can be found in the valley fill (alluvium) of the White River and its tributaries. Artesian springs are numerous and widespread in the county and are the result of saturated alluvial fill and un-pumped near surface aquifers.

Flood

RBC has participated in the National Flood Insurance Program (NFIP) since 1990. The program is designed to minimize the loss of life and property by identifying flood prone areas and regulating new development in areas likely to flood. Participation in NFIP guarantees that property owners in flood prone areas can obtain floodplain insurance. Without the county's participation in NFIP, property owners would be unable to purchase flood insurance. In addition, all federally connected loans, such as HUD, VA, FDIC, Fannie Mae, Farmer's Home Administration, Federal Housing Administration, Small Business Administration loans, etc., would be unavailable to residents without county participation. In return, the county is obligated to ensure that new development within the 100-year floodplain will be constructed in ways to minimize danger to life and property.

Development (including residences) is only allowed in the floodway fringe (floodplain) after receipt of approval (floodplain development permit) by the county. Development is generally prohibited in the floodway. The request for approval (permit) is based on plans that clearly show, and (when necessary) are certified by a licensed professional engineer or architect, that indicate the development will not create a flood hazard and can comply with RBC standards for development in the floodplain.

RBC continues to seek the implementation of non-structural flood hazard mitigation activities as a primary focus of good management practices however we realize that many times structural activities are the only viable options that will protect the community and will use data as efficiently as possible to find the best means to protect property and environment.

Floodplain Definitions

Insurance Rate Maps (FIRM): The 100-year flood, as defined by the Federal Emergency Management Agency (FEMA) and adopted by FEMA and RBC is the base flood used for floodplain management purposes. The flood maps prepared for RBC by FEMA identify the 100-year floodplain boundaries. RBC has an adopted set of floodplain regulations that apply to development in flood hazard areas and floodways that could be considered hazardous in all drainage areas of the County. Definition of 100-year flood is a specific streamflow that has a 1 percent (1 in 100) chance of being equaled or exceeded in any given year. The floodway is the normal channel of the stream plus that part of the adjacent inundated areas of the floodplain where, if stream velocities are obstructed, would create a damming or back water effect. This effect could produce a substantial increase in water levels; thus, inundating areas normally outside the 100-year floodplain. The area between the floodway and the 100-year floodplain boundary is defined as the floodway fringe. The floodway fringe is that area of the floodplain where velocities are small and obstructions can occur without increasing water surface elevation of the 100-year flood by more than one foot.

National Flood Insurance Program (NFIP): This is a federally-subsidized program that is available to any property owner in a participating community whether or not the structure is located in an identified flood hazard area on a community's Flood Insurance Rate Map (FIRM). Insurance is sold through private insurance agents. RBC is a participant in good standing in the NFIP. The National Flood Insurance Program (NFIP) is based on an agreement between local Colorado communities and the federal government. The community agrees to implement measures to reduce future flood risk to new construction and substantial improvements in identified Special Flood Hazard Areas as mapped by FEMA on a community's Flood Insurance Rate Map (FIRM). Then, FEMA makes flood insurance available within the community as a financial protection against flood losses when they occur. The insurance is designed to provide an alternative to disaster assistance to meet the escalating costs associated with the repair of structures and replacement of contents when damaged by a flood event. Until the establishment of the NFIP in 1968, flood insurance was generally unavailable from private sector insurance companies. Flood insurance claims information indicates that 35-40% of all NFIP claims come from outside the 100-year floodplain. The 100-year floodplain, as delineated on the community's FIRM, is the area which the community has agreed to regulate in exchange for flood insurance availability in the community.

Non-Structural Flood Hazard Mitigation in RBC

- National Flood Insurance Program (NFIP): Program benefits are available in RBC as described above.

- Floodplain Regulations: Upon entrance into the NFIP, RBC adopted the minimum standards of the program. Since detailed mapping, with floodways, had been prepared for the community, FEMA's "D" model ordinance was adopted. The regulations set performance standards by which development can occur in the community's identified floodplains.

Structural Flood Hazard Mitigation in RBC

Structural flood control projects in RBC have been limited to property owners and land management agencies carrying out limited bank stabilization, correction of in-stream features for habitat improvement and protection of irrigation diversion structures.

Federal flood control projects in RBC are nonexistent. Kenney Reservoir east of Rangely is not a flood control project and it is unknown whether the project has had an affect on flooding in the White River. Because the reservoir was not constructed for flood protection purposes it is believed it has had no significant effect on the 100 and 500-year floods. However, the reservoir may have reduced or eliminated flooding problems caused by ice jams near Rangely and sediment transport and the associated channel shift may have changed the floodplain. All assumptions in this regard need to be verified.

Flood Hazards

Three primary forms of flooding have been recorded in RBC. These are 1) spring thaw snowmelt; 2) monsoonal flash flood with sediment deposition; and 3) ice jamming during extreme winter cold events. Only one, spring flood flow, is consistent with mapping of the floodplain. The other two, ice jams and flashfloods have dynamic characteristics that have not been fully evaluated and mapped. Mapping on some dry streams has been distorted by the incisive cutting of the streambed by flash flooding. Without mitigation these three types of events will continue to result in flood related losses in RBC.

Spring Flows

The White River derives its water source from an area that is considered undeveloped forest with virtually no human population and includes the Flat Tops Wilderness. This area is a high alpine mesa with mountain peaks as high as 13,000 feet. During the winter months the upper watershed receives abundant moisture in the form of snow. When spring arrives a slow snow melt begins that rapidly escalates as it warms. The resulting high water runoff period can present very real flooding issues and varies with the intensity of the warm up. Spring runoff from snowmelt in the watershed east of Meeker accounts for the greatest sustained stream flow in the White River. The largest recorded flood in RBC occurred during spring flows along the White River on May 25, 1984. At that time discharge in the river near Meeker reached 6,950 cubic feet per second (cfs). By comparison, the minimum stream flows recorded in the White River near Meeker are less than 100 cfs.

The threat of extensive property damage from spring thaw is limited as the majority of land along the river has been developed for agricultural purposes. This historic pattern of developing river bottom lands for agricultural purposes means that only some older homes are in jeopardy of flooding. Newer homes have been precluded from the floodplain by adherence to floodplain regulations. Flood related damage is expected to be the result of channel shift, deposition of sediment onto farmland and erosion that causes infrastructure damage to bridges and roads.

Flash Flooding

The magnitude of flash flooding events in RBC is significant. Thunderstorms cause severe flooding, especially in the tributary basins of the White River. Yellow Creek, normally a small stream in the Piceance Basin, had an estimated instantaneous peak discharge of about 6,800 cfs on September 7, 1978. This unusual event was caused by a severe local thunderstorm. The stream flow of the brief event rivals the record flood of 1984 on the White River.

These events are the cause of serious erosion, property damage, and impact to infrastructure. In 2001 and 2002 severe flooding events occurred along County Road 5, spur roads off County Road 5, and areas on the west end of the County. These events result from monsoonal rains that come during August and September. The historic impacts of flash flooding are poorly documented although discussion with long time residents of the county indicates damage is a regular occurrence in the late summer. A pervasive attitude of living with the problem exists.

The drainage basins of Western RBC are representative of valley floors filled with a thick alluvium from the highly erosive soils of the surrounding lands. These alluviums make up the substrate on which the stream beds and riparian areas of the region are built. These alluviums are no more stable than the highly erosive soils from which they derive. For a number of reasons these creeks and riparian areas have become desiccated, de-vegetated, and ecologically unproductive. Subsequently the alluvium within the valley floor has become unstable and is easily eroded. These factors have combined to result in severe downward cutting within the creek beds leading to mini canyons that are very geologically young having occurred only within last 150 years. Flash flooding is accelerating this phenomena resulting in damage to infrastructure, deterioration of water quality, shrinkage of agricultural land and destruction of wildlife habitat. The process is accelerating in some areas as land disturbing activities increase. Additionally flash flooding is not just a characteristic water flow, but is a type of liquefied mud flow of severe intensity. Thus flood impacts include erosion and sediment deposition.

Recognition of the fragile and dynamic aspects of this environment has not been fully appreciated. The incremental and variable nature of erosion and incisive aggradation/degradation of stream beds is easily overlooked. Subsequently development and infrastructure has not been engineered to accommodate for these impacts. Roads and pipelines constructed several decades ago now face collapse as flash flooding and heavy rains have eroded the land and stream banks away. This problem is further complicated as infrastructure development is occurring in unmapped stream segments, or mapped floodplains that have dramatically changed, and/or involve federal/state/private land interfaces that raise jurisdictional issues.

The erosion issue has been recognized by the Natural Resource Conservation Service, Colorado State Geological Survey and local ranchers and land management agencies. Efforts at control have been directed at soil and land stabilization. Some stream stabilization in upper east Douglas creek has proven very successful. The rate of lost stream bank has diminished. These efforts have had a positive affect, however flash flooding still creates flood losses within the county.

Ice Jams

Ice jamming occurs along the White River every year and most of the time has little or no impact on property or infrastructure. The full extent and potential magnitude of this phenomenon are not well understood. Both Rangely and Meeker have historical data indicating periodic problem from ice jam/dam flooding. In recent years Rangely has been free of the problem and some have assumed it is the result of the construction of Kenney Reservoir upstream of the town.

Generally, ice jam flooding on the White River in Meeker occurs when a jam begins at a point about 0.2 miles downstream from the 10th St Bridge. Flooding occurs annually on portions of agricultural property in this area. Observations during the winter indicate that bank overflow because of jamming is fairly common on many agricultural lands along the river. This factor should be considered in future planning if any of these lands are developed for other uses.

The Flood Plan Information Report (1978) prepared for the Town of Meeker reported that there are no records indicating that ice jam flooding ever extended past Water Street. No loss of life has been attributed to ice jam flooding in Meeker. The report mentions a possible ice jam flood in 1952, but this event has not been confirmed. An ice jam did occur in 1962, but no information on stages or damages was found. The ice jam event of 1973 occurred after a period of extreme cold and resulted in the flooding of the Findlay Trailer Court located upstream from the 5th St Bridge, between Water St. and the river. Several of the waste lines connecting the trailers to the sewage system were uncapped allowing floodwaters to enter the sewage system and overwhelming the wastewater treatment plant. The plant, although surrounded by a dike, was also threatened by high water levels downstream from the 10th St Bridge, which nearly overtopped the dike. Seepage through the dike was observed.

Damages were estimated at about $10,000. Following this ice jam, the waste lines were capped and extra pumps were added to decrease the possibility of flooding at the plant. Sandbags were added to the dike during the flood and its height was increased at a later date.

In January 1979 an ice jam formed following a cold spell. This ice jam caused the most damage in recent memory. Flood waters reached a higher stage than during the 1973 event; approaching Water Street. Several trailers and homes in the Findlay Trailer Court were flooded. Damages were estimated at between $50,000 and $100,000. This figure includes damage to three water pump motors located along the bank of the White River that had to be repaired. Ice reached the low chord of the 5th St Bridge, but the bridge was not damaged. Ice jams occurring in February 1982 resulted in over bank flow into the 5th St Park and the grazing lands upstream. Since that time, some fill has been placed along the river in the vicinity of the Findlay Trailer Court. Sulphur Creek which runs perpendicular to the White River just upstream from the trailer court was channelized between Rte 13 and the White River in 1987. The channelization project included a 100 ft long stilling basin at the confluence of Sulphur Creek and the White River with vertical concrete walls approximately 11 ft high lining the stilling basin to contain a 100 year flood.

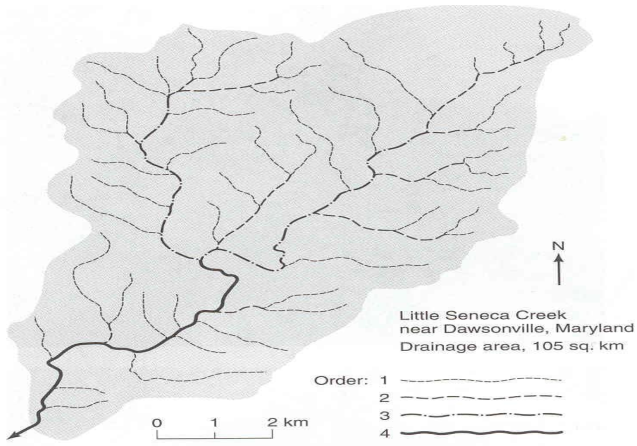
In 1989, flooding from an ice jam spilled over into the park on the left bank of the river rather than the trailer court on the right bank. This may have been due to the configuration of this particular ice jam, but may also have been affected by the fill or by the Sulphur Creek channelization project. The Town of meeker replaced the 10th street bridge in 1997. The bridge replacement was engineered by Carter Burgess Engineering. The Town of Meeker and Carter Burgess worked closely with the CWCB and Corp of Engineers to design the new bridge to mitigate ice jam problems that had been enhanced due to the pillars located in the middle of the old bridge extending into the middle of the White River. The original bridge was shorter and therefore the channel was narrower under the bridge. Mitigation included constructing a free span bridge with no pillars constructed in the river and widening the bridge to open the channel to its natural state.

In 2001 an ice jam occurred in the same general area as in the past near the start of the site at City Park on the south side of the river. Water overflowed into the park and was backed up under the 5th street bridge. Observations of the river during this event showed frazil and aufice type ice to be occurring within the channel at the 10th street bridge, forcing water and ice out progressively east. Water was forced out near the area of seventh and eighth street on the north side of the river threatening a small number of residential structures. Overflow occurred below the 10th Street bridge on the west and north side of the river into the Smith field and up to the edge of the berm protecting the wastewater treatment plant. Water sought level in existing irrigation canals. The canals provided pressure relief reducing some potential impact to property. From approximately February first to the tenth, water and ice rose and fell an average of 5 to 6 feet per day from a baseline point of 15 feet above the river bed. The weather during this period was very similar to the event that occurred in '89 and some have said the 1970's. These events correspond to a warning followed by a smooth extreme cold. They appear to be partly caused by available ice in the river after a warming period that provides material to promote jamming. Interestingly these periods also correspond to periods of drought within the region

Mitigation and Methodology for Determining Risk of Flooding

In this plan mitigation priorities have been derived from analysis of flood risk. Risk is characterized based on the extent and character of hazards and the vulnerability features of value have to those hazards. High risk is considered any situation and/or area where features of value have a considerable potential for loss in flood. A value is considered anything that would require replacement, and/or is irreplaceable and includes infrastructure, buildings, persons, habitat, endangered species, et cetera. Low risk is considered any situation and/or area where features of value have a small potential for loss in a flood. It should be noted that a situation or area can have a very high potential hazard and be low risk as no features of value are threatened.

The scale picked to plot risk in this plan is the drainage sub-basin. This is the basic area of drainage for second and third order streams using a characterization as described on Figure 3. Because the majority of the county is the drainage basin for the White River, the White River is considered a fourth order stream using this characterization scheme. The second and third order basins are represented on Map 3.



Channel network of Little Seneca Creek above Dawsonville, Maryland. Stream orders are indicated by different symbols.

Figure 3 (Leopold, 1997)

For each of these second and third order sub-basins hazard and vulnerability has been assessed. For hazard analysis, basic flood impact based on a weighted value for frequency of flood events has been plotted against historical impacts for each flood type. Table 1 is an example of how weights are recorded for impacts in each sub-basin.

Table 1: Example of Hazard Analysis Record for a Sub-Basin.

Basin Description:	Spring Flow	Ice Jam	Flash Flood
• Bank Over-flow	2	4	1
• Threatened Structures	1	1	2
• Impaired Ag Land	3	3	1
• Infrastructure Damage	0	0	0
• Industrial Interruption	2	2	2
• Incisive Erosion	4	2	1
• Bank Erosion	2	2	1
• Invasive Species	2	1	1
• Channel Shift	2	3	1
• Habitat Destruction	3	1	1
• Quality Impairment	4	1	1

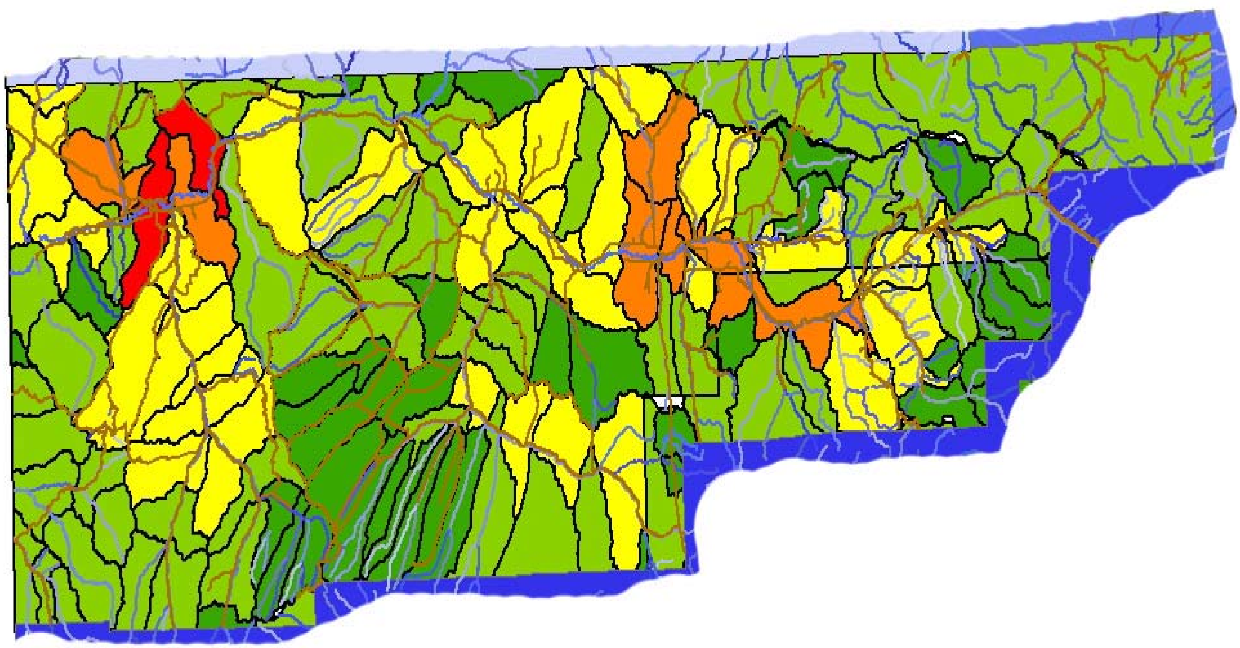
The weighting values for frequency used to determine hazard are as follows:

5 = Frequent event and/or result because of flooding (yearly and/or every several years).
4 = Common event and/or result because of flooding (every several years).
3 = Occasional event and/or result because of flooding (in every 10 years), or unknown.
2 = Rare event and/or result because of flooding (The 50 to 110 year event).
1 = Generational event and/or result because of flooding (100 + years).
0 = No data.

The resulting values have been plotted using a geographic information system to provide a basis for understanding potential hazard. Vulnerability, defined as potential damage to existing and/or future predictable features of value, have then been added to potential hazard. The weighted values for potential damage (basis for measurement of vulnerability) are as follows:

Rating of 1 = Low potential and/or no data Rating of 2 = Minor damage potential. Rating of 3 = Moderate damage potential. Rating of 4 = High damage potential. Rating of 5 = Severe damage potential.

The resulting sum of weighted values provides a basis for assigning risk. The final value for a high risk basin means: an area that has frequent flooding with an identified set of historical impacts that has a high potential to create further loss to known features of value. A low risk basin is the opposite. Risk assignment is represented on the following Map 3.



Map 3: (Red indicates areas of highest risk, green the lowest.)

Avalanche

A snow avalanche is a mass of snow, ice, and debris flowing and sliding rapidly down a steep slope. Snow avalanches occur in the high mountains of Colorado during the winter as the result of heavy snow accumulations on steep slopes. When the snow pack becomes unstable, it suddenly releases and rapidly descends down slope either over a wide area or concentrated in an avalanche track. Avalanches reach speeds of up to 200 miles an hour and can exert forces great enough to destroy structures and uproot or snap off large trees. Rio Blanco County has conditions that are conducive to avalanches and deaths have occurred in the back country due to triggering of avalanches (2002). In general the area of avalanche hazard in RBC is in the eastern end on federal lands that are not developed. A minor risk exists on some adjoining private property although the likelihood of an avalanche is remote. No structures are known to be threatened by avalanches in RBC as of 2003. Snow avalanches imperil cross-country skiers and snowmobilers.

The cheapest and safest way to prevent property damage and save lives is to stay out of avalanche paths and runout zones in winter. Methods of avalanche control include directional control of blowing and drifting snow by erecting snow fences to keep it away from the starting zone; planned release of small snowslides with explosives before the snow accumulation increases their destructive potential to unmanageable proportions; building snow sheds over particularly dangerous sections of railroad and highways. Sometimes diversion structures can divide an avalanche and minimize its impact. Avalanche warnings are common in Colorado, but they do not remove the peril, only alert one to it. Except for public notice no other avalanche mitigation is used in RBC.

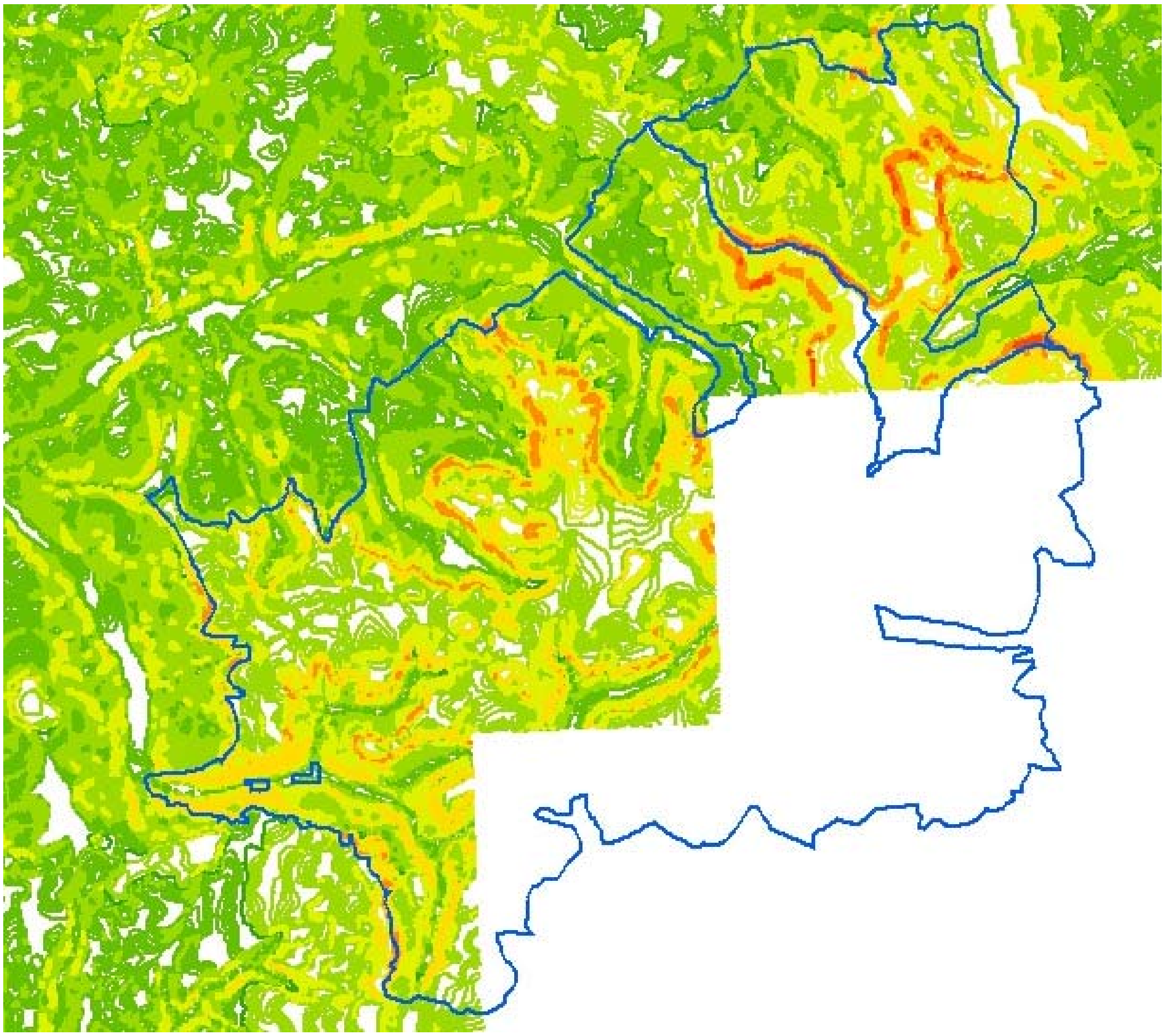
Mitigation and Methodology for Determining Risk for Avalanche

Snow avalanches are the rapid downslope movement of snow, ice, and associated debris such as rocks and vegetation. "The forces generated by moderate or large avalanches can damage or destroy most manmade structures and the “debris from even small avalanches is enough to block a highway or railroad” (Martinelli, 1974, p. 5). Avalanches occur in the mountainous areas of Colorado generally above 8,000 ft. elevation, and most commonly occur from November through April. Avalanche occurrence is directly related to topography, climate, vegetation and aspect of the area. The methodology for determining avalanche hazard in this plan is a simple intersect of elevation and slope and the addition of the two weighted factors used for each parameter.

The following tables describe the weights used for each parameter in the model:

Parameter	Factor	Weight
Elevation (contour)	12000+	4
	11000+	3
	10000+	2
	9000-	1
Slope (angle)	0-15%	1
	15-33%	2
	33-50%	3
	50+%	4

The basic model information provides a fairly good fit with conditions on the ground. Values are then added to the map to determine if and where risk situations exist. As with all model information verification through field observation is necessary before a decision is made about application of mitigation and/or regulation. From the existing data virtually all the potential dangerous avalanche situations are on White River Forest and/or in the Flat Tops Wilderness. The following map is an example of avalanche hazard areas in the Flat Top Wilderness (outlined in blue) in and on the border of RBC.



Avalanches start most frequently on slopes with average gradients of 30 to 45 degrees. Slopes steeper than 45 degrees usually do not accumulate enough snow to produce very large avalanches in the Rocky Mountain climate. Avalanches may start on slopes of less than 30 degrees if the snow is highly unstable as the result of a prolonged warming trend, heavy snowfall, or unusual wind condition. These starting zone slope angles are, however, merely the range in which most dangerous avalanches occur and it is not assumed that slopes outside this range are safe from avalanches. Because of the wide distribution and shallow data on avalanche activity in RBC all potential areas of activity have been considered.

Avalanche Mitigation Considerations

By far the most reliable way of locating avalanche areas is to study long-term, detailed records of past events when they are available. Such records are available for many localities in Europe, but unfortunately, compilation is just starting in Colorado. Usually, data on the location, frequency, or severity of avalanche activity are completely lacking when new areas are considered for highways, winter sports, mining operations, or mountain home sites. Without adequate records of past events, the best alternative is to obtain what data are available, examine the area, map all recognizable paths, estimate the frequency and intensity of the avalanche action, and if possible, start a record of avalanche events. Active or recently active avalanche paths are most easily identified on air photos or from low-flying airplanes or helicopters. The next best viewpoint is the slope or ridge across the valley from the suspected avalanche area. The entire path should be viewed from such vantage points so that there is less chance of misjudging the size of the path or of overlooking an indistinct or inconspicuous path. Such an overall view makes it possible to spot paths where the aspect of the starting zone and the track are different—an important feature in determining what wind direction causes deposition in the starting zone. Surveys from the valley bottom or lower slopes (the usual road location) are often very misleading. Crooked paths or those with a short, steep pitch in the lower track or runout zone often appear much shorter and smaller than they really are or may not even be recognized as avalanche paths.

In the summer avalanche paths in forested areas usually appear as strips straight down the mountain, characterized by a different type or age of the dominant vegetation. These vertical swaths through the trees can be very dramatic when the change is from natural timber to grasses and small herbs. They are less conspicuous but still obvious to most observers when the change is from conifers to aspen or brush. On the other hand, careful scrutiny and often a distant vantage point are needed to spot the change from mature timber to younger trees of the same species.

In some cases, avalanches run down slopes with only scattered trees or open park-like stands of trees. These paths are hard to see, and only long and complete records will reveal all of them. Suspected areas should be checked carefully for evidence of avalanche activity. Good indicators of avalanche activity are trees with scars or broken limbs on the uphill side, or trees that lean downhill. Leaning trees deserve a second look, however, to be sure avalanches and not snow or soil creep or a landslide causes them. An accumulation of wood debris on lower slopes or in the valley may mark an avalanche run-out zone, as might a patch of aspen or young trees at the bottom of a likely avalanche path. Patches of downed trees all aligned in the same direction are a good indication of avalanche activity. Do not discount such patches of downed trees because their tops point uphill. They may mark areas of air-blast, or they may be the result of an avalanche that crossed the valley and ran part way up the opposite slope. Summer identification of avalanche paths in non-forested areas is difficult and uncertain. Slope steepness, aspect, and surface roughness all offer clues but no proof. Other things being equal, avalanches will be more likely:

On lee slopes than on windward slopes, because of wind loading; on grass slopes than on brush-covered slopes, because of lowersurface roughness; On shaded northern slopes than on sunny southern slopes, because the snow stays loose and unstable longer; and On slopes between 30 degrees and 45 degrees than on steeper or gentler slopes because of their ability to accumulate sufficient snow on terrain steep enough to avalanche readily. Large patches of bare soil surrounded on the sides and above by vegetation, if located on slopes steep enough to avalanche, should be considered possible avalanche starting zones. This lack of vegetation is often due to deep snow accumulation. Steep rock faces or cliffs that have numerous benches or pockets where snow can accumulate may also be the sources of avalanches in spite of the general statement that very steep slopes usually are not serious avalanche problems. Many avalanche paths cross both non-forested and forested areas. In the Rocky Mountains, for example, many avalanches start above timberline, their track in the timber. In such cases, the swath through the trees is the most obvious identification feature, but the starting and run-out zones must be given full consideration when establishing size and estimating frequency and intensity of activity.

Not all avalanche paths run every year. any run only once every 5 to 15 years, and others even less frequently. Nor do all avalanches run the full length of their paths every time. Avalanches may stop in the starting zone, track, or run-out zone, depending on the amount and condition of the snow in the path. Field evidence—usually confined to the starting zone—that an avalanche has occurred includes:

- A fracture line or fracture face where the unstable snow broke away as a slab avalanche from the remaining snow cover. This is the most frequently observed and perhaps the most important, single, winter identification feature. The continuity of these fracture lines makes even small ones visible for great distances. New snowfall or drifting snow, however, soon obscures shallow fracture lines and makes even large ones much less distinct.
- A change in snow depth and in the texture and features of the snow surface, without a distinct fracture face. All of these features, which mark the start of a loose snow avalanche, are quickly erased by snowfall and drifting snow, and may be missed even by a careful observer. Additional evidence of avalanches—features that may be located in the starting zone, track, or run-out zone, and whose size and location in the path are clues to the size of the avalanche – includes:
- Mounds of blocks of snow. Major concentrations usually mark the lower end of the avalanche. Lesser amounts may be scattered higher on the path, at breaks in the slopes, or curved in the track. This is the second most important winter identification feature.
- Snow dirtier and denser than the surrounding cover. At times, even after avalanche debris has been covered by fresh snow and all surface indications of avalanche debris are lost, a ski tip or pole or a probe rod can detect the harder, denser avalanche snow beneath. In late spring or summer, these deeper and denser snow deposits often persist after the surrounding cover has melted, and they make excellent identification features. It may be difficult, however, to tell if the debris is from one or more avalanches on the same path.
- A clean white swath through gray or dust-covered snow in steep terrain. After snow surfaces have become dust covered or modified by weather during long snow-free periods, the removal of these surface layers by avalanches reveals the clean, unmodified snow beneath. The change in color and texture is noticeable, even if the avalanche left little other evidence.
- Accumulations of broken trees, limbs, twigs, leaves, and needles. Entire trees may be uprooted, broken off, or bent over and are usually oriented parallel to the down-slope direction. Large amounts of timber in the debris indicate an avalanche that ran larger than usual or took a different route down the mountain.
- Snow, mud, rock, or detached tree limbs plastered against uphill side of standing trees or rocks. These signs often help mark the outer edges of the moving snow. They are most noticeable just after an avalanche has run and are quick to disappear.
- Deep grooves in the snow and walls of snow; both usually oriented down the fall line. These indicated avalanches in heavy, wet snow. Grooves and sides of walls are usually smooth and icy. These features are more common in spring avalanches than in winter ones.
- "Flag trees" with fresh scars or broken limbs on uphill side of standing trees, and brush with healthy limbs confined to the downhill side. Confusion with wind-damaged trees can be avoided by a complete investigation of the site containing such "flag trees."

After an avalanche path has been located, it is important to know the size and frequency of avalanches on the path. Long-term observation is the best way to establish avalanche frequency and size. These are, however, available for only a few locations in the United States. The next best thing is to systematically observe the destructive effects of avalanches on the terrain <u>during snow-free conditions.</u> Sometimes, evidence may be found of multiple avalanche events of various sizes and ages through a careful analysis of destruction in the avalanche track and through the distribution of debris in the run-out zone. Additional sources of information may come form "old timers" in the area. Highway maintenance crews, power-line crews, ranchers, trappers, hunters, or fishermen should be quizzed. In more remote areas, ski touring, snow mobiling, or winter mountaineering groups may be a better source of information. Newspaper and other written accounts occasionally help in establishing the data of major events, but are selective toward very large avalanches or those that took lives or did extensive damage.
All incomplete records will be selective in one way or another, and must be used with caution. Highway crews will be most concerned with slides across the road and will seldom pay much attention to those that

do not reach the road. Sportsmen will be more apt to see the early avalanches that run during hunting season or those that leave large debris cones that persist in the valley well into fishing season. Such accounts are not definitive in establishing avalanche frequency.

Extreme Snow

The eastern side of RBC is mountainous and receives snow amounts comparable with those of other mountainous regions of the state. RBC is prepared for severe snow amounts as a matter of course. Avalanches are directly related to the amount of snow, however, weather conditions also play are part in snow stability. The towns of Meeker and Rangely and county residences are prepared for extraordinary snow events and mitigation activities are not anticipated as needed beyond public outreach as a preparedness measure outlined through the broader emergency management program. Additionally road plowing is evaluated and emergency response is considered as development occurs within the county. No modeling has been deemed reasonable for this natural event and no hazard maps have been created except for avalanche.

Meteorological/Biomorphic Related Natural Hazard Events

Wildfire

Rio Blanco County Colorado has some of the highest risk indexes for probability of wildfire events and impacts from these events as any county within the state of Colorado (Neuenschwander et al. 2000, Despain et al. 2000). A very large percentage of the land within the County is owned by the federal government (73%) and it encompasses a diverse range of ecological zones and land uses. Because of the reasonably high possibility for wildfire events and the overwhelming preponderance of federal property impact from wildfire varies based a number of different factors throughout the County. Traditionally, wildfire has been suppressed and not unlike in many areas of the West this suppression activity has lead to ever-increasing problem. Ecosystems have not been allowed to follow a natural course and burn regularly and have subsequently become increasingly clogged by high fuel loads. The number of problems resulting from the many years of suppression management has led to an increasing number of fires throughout the west and an acknowledgement that a more comprehensive program of wildfire management needs to be implemented to balance ecosystems, land uses, and watersheds. This is in large part an acknowledgment that if we do no more than respond to disasters, problems will reoccur and as the last several years attests fire will become large and more catastrophic (Sampson et al. 2000).

Recognition of the significance of wildfire problems in the West has resulted in a National Fire Plan being created by the Agriculture and Interior Departments. Congress has supported the plan through funding and requiring a 10 year Comprehensive Strategy be put in place. As part of the 10 year Comprehensive Strategy Congress has directed the Secretaries of the Interior and Agriculture to work with the Governors to develop this strategy. In the FY 2001 Interior and Related Agencies Appropriations Act (P.L. 106-291) Congress directed that "close collaboration among citizens and governments at all levels," be a key component in wildfire planning.

In accord with these directives the Western Governors have promulgated a strategy for development of wildfire plans in communities of the West. The strategy, "A Collaborative Approach for Reducing Wildfire Risks to Communities and the Environment" establishes a set of core principles for use as goals in implementation of this strategy. The report states that:

> these principles include such concepts as collaboration, priority setting, and accountability. An open, collaborative process among multiple levels of government and a range of interests will characterize the fulfillment of this strategy. The end results sought by all stakeholders are healthier watersheds, enhanced community protection, and diminished risk and consequences of severe wildland fires. The primary goals of the 10-Year Comprehensive Strategy are:
>
> 1. *Improve Prevention and Suppression*
> 2. *Reduce Hazardous Fuels*
> 3. *Restore Fire Adapted Ecosystems*
> 4. *Promote Community Assistance'*

This section of the pre-disaster mitigation plan reflects and builds on Rio Blanco County's Strategic Wildfire Management Plan and is part of an approach for fulfilling the relevant goals of an integrated emergency management system. It addresses mitigation and will touch upon preparedness, response and recovery. The wildfire program is an integrated set of plans, processes, standards, strategies, approaches, actions, and recommendations for projects and activities that when implemented will eliminate or reduce future wildfire hazards and losses. Long range planning is one of the key ways to break the "suppress natural thinning-amplify fuels- suppress natural thinning cycle." Active adoption of the strategies being discussed in this plan and following the established direction outlined in the wildfire program can help ensure that Rio Blanco County communities will be able to better manage and/or eliminate the kinds of economic distress, endangerment to life, and environmental degradation that often accompanies wildfire.

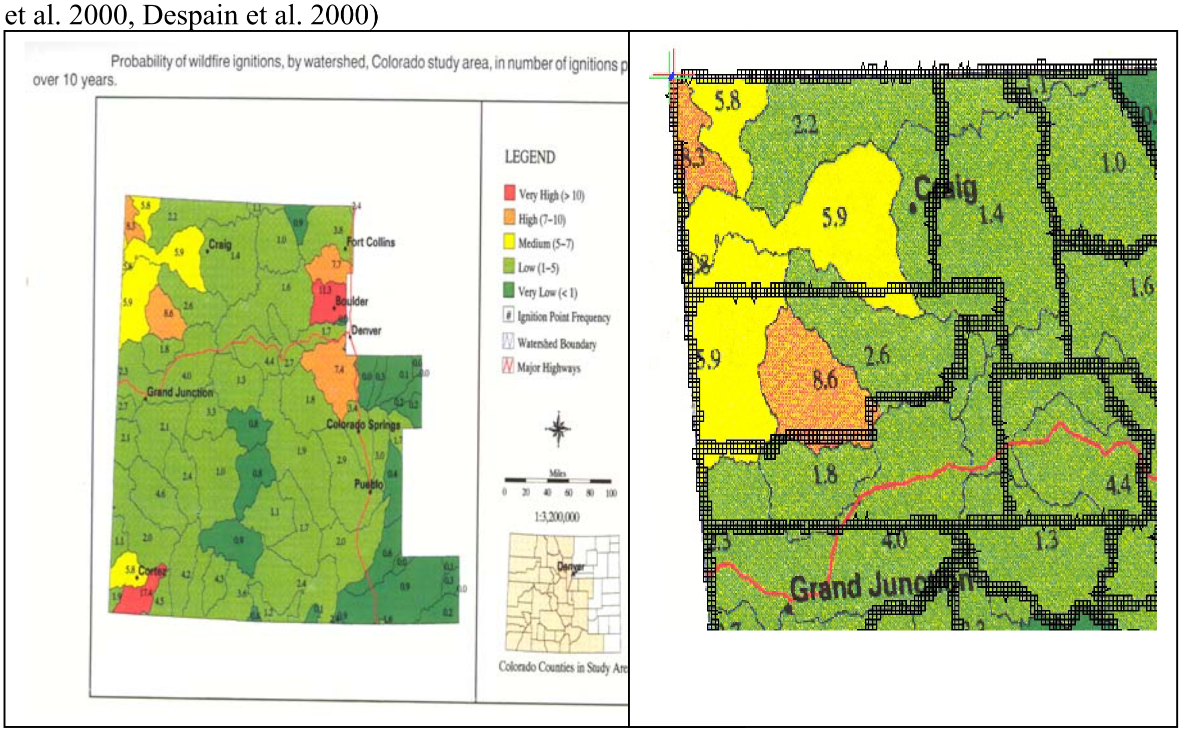
Wildfire Hazard Types

Two primary forms of wildfire occurrence can be noted for RBC. These are 1) normal periodicity wildfires; 2) drought related wildfires. Only one, normal periodicity wildfires are consistent with mapping of the wildfire hazard risks. Drought related wildfires have dynamic characteristics that are not fully understood and are unpredictable. These events tend to shift the hazards into the higher regions of the county that under normal conditions do not burn with the frequency seen in the western regions of the county. However, wildfire is a very common occurrence within the county and can occur under the right conditions in any place. Without mitigation wildfire events will continue to result in fire related losses in RBC.

<u>Normal Periodicity Wildfires</u>

During normal years wildfire starts are numerous in the western end of RBC. These wildfires are for the most part on public land slated for multiple use or private ranch lands. They are largely the result of dry lighting strikes (BLM) and every year several of the events conflagrate into fires covering thousands of acres. For the most part these fire events fall into the category of fire use and have little potential impact on the local communities. The exceptions are a threat to mining and oil and gas infrastructure (electrical lines) and some areas around Meeker where a severe residential interface is arising. At present this interface is small and the number of homes limited. If the County and Town of Meeker do not diligently impose standards for home protection, and in some cases proactively address this interface with mitigation by reducing fuel loads, in the future, this area could become the location of wildfire disasters.

Normal periodicity wildfires follow a pattern of hazard as represented on this Figure 1 ((Neuenschwander et al. 2000, Despain et al. 2000)



Drought Related Wildfires

Under normal conditions the western end of the County is under the greatest threat of wildfires; however, when fuel loads dry out and normal precipitation patterns drop the eastern end forests throughout the Flattops Wilderness and White River National Forest become extremely dangerous. The moisture in the fuels loads in these forests are normally low to begin with (Frary, personal communication) so drought severely exacerbates the situation. The 2002 fire season exemplifies this phenomenon as the western end of the County saw a reduction in overall fires while the eastern end saw a major event in the Big Fish Fire that consumed over ten thousand acres of old growth forest. Except for the loss of the recreational structure of Trappers Lake Lodge, this fire was a fire use fire and can be considered a normal and natural event. Drought conditions can be expected on a regular cycle in Colorado (CSU 2002). Wildfire mitigation cannot be premised on potential drought as moisture variability is too great and unpredictable for practical management. In planning mitigation strategies the assumption used is that if the fuel conditions exist to cause a high hazard this will be the primary driver for potential fire. The assumption is only modified based on slope and aspect.

Mitigation and Methodology for Determining Hazard and Risk for Wildland Fire

Wildfire mitigation priorities have been derived from analysis of wildfire risk. Risk is characterized based on the extent and character of hazards and the vulnerability features of value have to those hazards. High risk is considered any situation and/or area where features of value have a considerable potential for loss from wildfire. A value is considered anything that would require replacement, and/or is irreplaceable and includes infrastructure, buildings, persons, habitat, endangered species, et cetera. Low risk is considered any situation and/or area where features of value have a small potential for loss in a wildfire. It should be noted that a situation or area can have a very high potential hazard and be low risk as no features of value are threatened.

The scale picked to plot hazard for wildfire in this plan is vegetation mapping as plotted in GIS coverage's from the National Biological Survey (NBS 1976), USEPA Vegetation, Ecology, and Land Use (1993) and USGS Arial digital ortho-photography (1991-1994). The NBS and USEPA data sets were intersected using ESRI's ArcInfo GIS to provide a vegetation layer. Basic calibration of this layer was accomplished through course overlay onto USGS digital othro quarter quads. A weighted factor based on fuel burn efficiency was applied to vegetation types for these datasets. A weighed factor of the probability to have a wildfire for aspect (360 degrees USGS 1990) and slope (% slope USGS DEM), based on Campbell (1991) was intersected with the vegetation layers to provide a hazard rating. The calculation used is based on intersect of Index (NBS) with Veg (EPA); intersected with intersect of Angle (% slope USGS DEM) with Rate (360 degrees USGS 1990) analyzed as (I+V) x (A+R)= Wildfire Hazard. Layers of known ignition and fires for the last ten years (BLM), properties by type and generic value (RBC), gas/oil wells (COOGC), bridges, roads, electrical lines (WREA) were overlaid on the model map and risk analyzed.

The following tables describe the weights used for each parameter in the model:

Index	Weights (under the right conditions)	Type
5	Very prone to fire	Forest/Spruce/Fir/Pine/Evergreen/Pinyon Juniper
4	Highly prone	Forest/Range/Pinyon JuniperOak/Mixed Shrub/Sage
3	Moderately prone	Range/Ag/Oak/Mixed Shrub/Sage/Grass
2	Minor prone	Range/Ag/Pasture/Grass/Light Sage-Shrub
1	Not prone	Barren/Water/Rock/Tundra

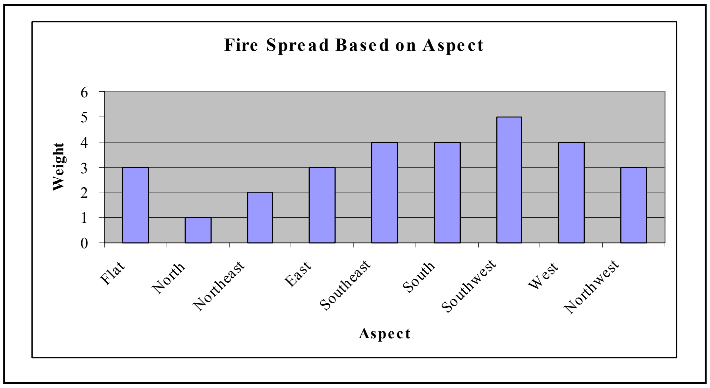
(US National Biological Survey 1976, USGS Arial Photo, EPA 1993)

Slope %	Angle	Weights
0-3	1	Low burn movement
3-8	2	More rapid burn flow
8-15	3	Increasing burn flow
15-33	4	High burn flow
33-50	5	Rapid burn flow
50+	6	Very rapid burn flow

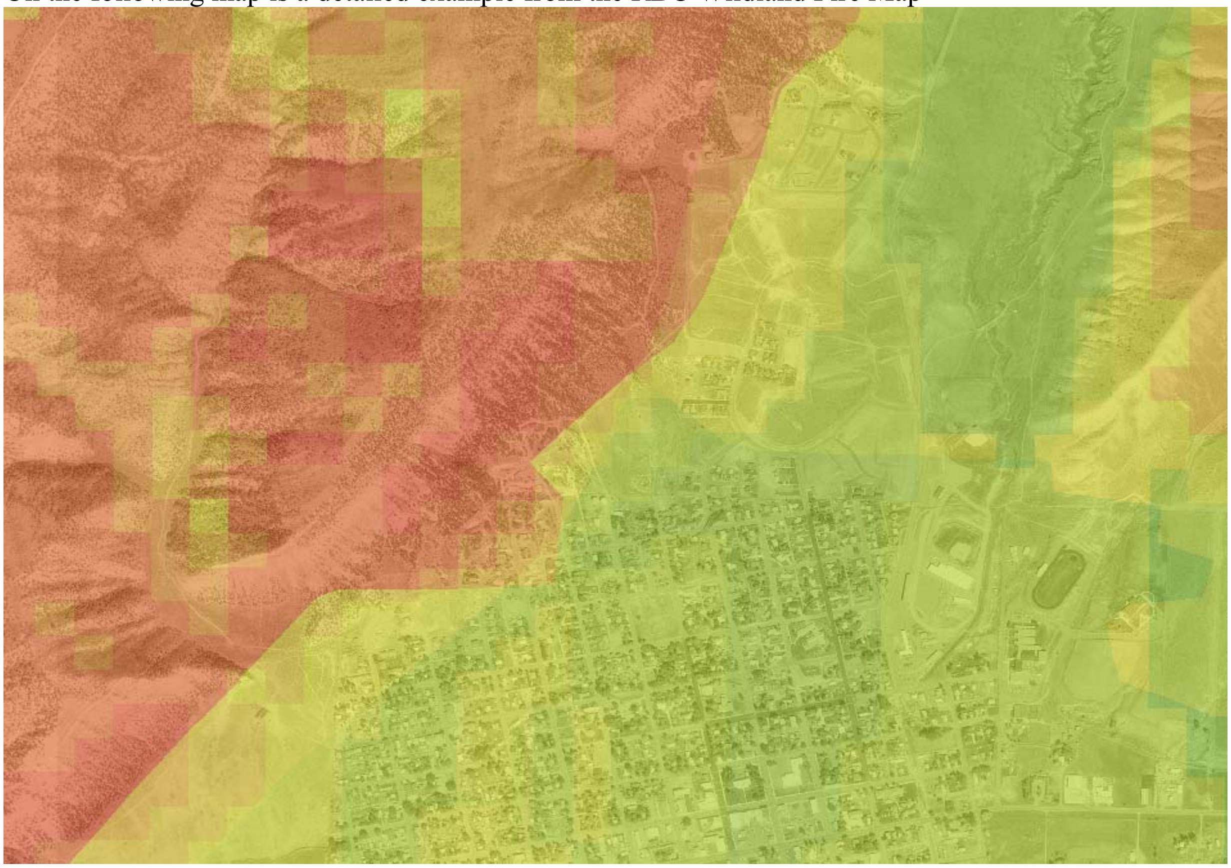
(USGS DEM)

Aspect	Weight
Southwest	5
South	4
Southeast	4
West	4
Northwest	3
East	3
Flat	3
Northeast	2
North	1

(Based on Campbell 1991)



On the following map is a detailed example from the RBC Wildland Fire Map



Extreme Meteorological Conditions

Extreme meteorological conditions are those that are out of the range of that which is ordinarily encountered. They are mentioned in this plan because they are natural hazards in their own right and/or are major contributors in intensifying other natural hazard events such as ice jamming.

<u>Extreme Cold</u>

For the most part the communities in RBC are prepared for extreme cold. RBC is in a mountainous region that is typified by winter extremes. These winter extremes include snow and cold. Because of the rural and isolated nature of the communities in RBC extreme cold does not pose a great threat. Threat to the communities would occur only under conditions that would create situations such as disruption of utility services. Extreme cold temperatures often accompany winter storms however these are so common in the RBC that predicting a threatening event is almost impossible. Because of this a modeled risk analysis has not been performed and mitigation will entail preparedness and public outreach.

<u>Extreme Heat</u>

From 1979 to 1999 excessive heat exposure caused 8,015 deaths in the United States. During this period, more people in this country died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined. In RBC extreme heat has not historically been a cuase of death however this can occur. Generally speaking heat related illness that does occur will be during normal periods when people do not take care to prevent heat exhaustion and other heat related problems. Extreme heat waves are a rarity. During a period of extreme heat the elderly, the very young and people with mental illness and chronic diseases are at highest risk. However, even young and healthy individuals can succumb to heat if they participate in strenuous physical activities during hot weather. People suffer heat-related illness when their bodies are unable to compensate and properly cool themselves. The body normally cools itself by sweating. But under some conditions, sweating just isn't enough. In such cases, a person's body temperature rises rapidly. Very high body temperatures may damage the brain or other vital organs. Several factors affect the body's ability to cool itself during extremely hot weather. When the humidity is high, sweat will not evaporate as quickly, preventing the body from releasing heat quickly. Other conditions related to risk include age (the elderly and young children), obesity, fever, dehydration, heart disease, mental illness, poor circulation, sunburn, and prescription drug use and alcohol use. Since humidity is usually low in the western end of the RBC the foregoing problem is not common. On the eastern end of RBC the humidity is higher however the temperatures are low. For the same reason extreme cold is not modeled extreme heat has not been modeled and mitigation will entail preparedness and public outreach.

<u>Drought</u>

Drought is unique among natural hazards because it is not a clear event, like a flood, earthquake, hurricane or tornado. These events strike, leave their mark, and are gone. A drought, however, sneaks up quietly disguised as lovely, sunny weather. Like many natural disasters it can be plotted on a map and does have a beginning and end, however its duration is unpredicatable and unlike a tornado it can be considered a chronic rather than catastrophic event. It is difficult to know when a drought will begin until it is already underway, and often impossible to tell when it ends. Any day when it doesn't rain or snow (which describes the majority of days in Colorado) could be the beginning of the next drought.

Drought is a concept that is both simple and complex. Drought is a shortage of water, usually associated with a deficiency of precipitation. Drought occurs when demand for water exceeds the supply of water. Whether a drought can is the cause of disaster depends on a complex set of circumstances as different types of demands require different amounts of water in different forms at different times of the year. Droughts are often defined by their impacts, e.g. on crops or on reservoir water levels, and power availability. Thus, there is no universal definition of a drought. The more diverse the economy and the climate of a region are, the harder it is to define drought. Drought means different things to different people; one person's drought can be another person's "sunny day." Drought is also "relative" and must be defined in terms of what is "normal" for a particular region or time of year. To someone who has lived in Nevada or Arizona, Colorado looks green and lush, however compared to the eastern half of the United States Colorado experiences perpetual drought. In fact, for most locations east of Omaha or Kansas City, the driest year on record may still be wetter than the wettest year on record for most of Colorado's lower elevations.

RBC is always in a perpetual drought in the western section as this area is technically defined as a desert. The important measure is whether a shortage of water will impact nature and society in the county. This is particularly important in regard to how large an impact may occur during the wildfire season. These impacts may change over time as mitigation measures are developed and the results of dryness are addressed and the landscape is restored to a firewise condition and the community is designed to be drought resistant. For RBC drought mitigation is largely dependent on success in mitigating other identified hazards in this plan.

Invasive Species

"Noxious weed" is a legally defined term that refers to a specific plant species which has been designated for mandatory control by branches of local, state or federal government due to the harm, actual or potential, that the species is capable of inflicting upon the resources and values of society. To be designated as a noxious weed by state or local governments in Colorado, the species must be non-native to the state and meet one or more of these criteria:
(a) Aggressively invades or is detrimental to economic crops or native plant communities;
(b) Is poisonous to livestock;
(c) Is a carrier of detrimental insects, diseases or parasites; or
(d) The direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems.

The inclusion of "Noxious weed" and invasive species in this plan is based on the synergistic affect these plants have on the natural hazards of erosion, flooding, and wildfire. Management of these plants as a natural hazard may deter or eliminate the development of other hazard phenomena. Of particular concern in this regard are cheatgrass as a fine fuel for wildfire and tamarisk as a contributor to riparian instability changing the dynamic of flooding and wildfire. Additionally they are a natural hazard in their own right that requires mitigation. All mitigation activities involving weeds addressed in this plan recognize these synergistic affects and build on the benefit of linking this program with those of other RBC programs already in existence and operating.

Geological/Geomorphic Natural Hazard Related Events

Stability of the surface of the earth is driven by a number of factors and is in reality a misnomer as erosional, depositional and other restructuring forces of nature have rearranged the land for millions of years. In RBC the land is generally unstable and very erosive. This leads to a host of problems and potential issues. For example debris flows are very common throughout the county particularly in the central and western sections. In RBC land stability is an issue and has to be considered during development review. Seven primary stability issues have been identified in RBC. These are:

- debris flow/fans;
- erosion/deposition;
- landslide;
- rockfall;
- swelling soils;
- collapsing soils;
- and sinkholes.

The following is in part taken from publications of the Colorado Geological Survey and John White of CGS-2003.

Debris Flows/Fans

Past debris flows can be recognized by existing debris fans that reveal themselves as sloping, wedge-shaped deposit of loose rock, earth and vegetative debris near or at the junction of a smaller stream with a larger stream valley, or where the gradient of a stream abruptly decreases. They are created by debris flows that are downstream/downslope propulsion of rocks, vegetative matter, junk and other material in a watery, muddy slurry. The stream that deposited the fan from a flow normally runs into or traverses along one of the edges of the fan. Debris flows present serious dangers as they, like avalanches, can occur with tremendous force and can dislodge and demolish infrastructure, buildings, and cultivated land. On July 24, 1977, an intense rainstorm drenched Glenwood Springs and the steep slopes above the town. It generated debris flows that caused a reported $2 million in damage in the southern part of the city. Remarkably, there were no reported injuries as tons of red rock and other material, loosened by the rainfall, swept down the scenic mountainside into homes and other buildings, severely damaging them. The financial loss, much of it borne by city and Garfield County taxpayers, could have been averted with proper development planning on a known debris fan and its periphery. These same conditions exist in RBC.

In many stream valleys, the debris fans, built up over the centuries at the mouth of the small tributaries, offer attractive places for development. Frequently, in an effort to avoid mainstream flooding, the debris fans are built upon without the realization that they, too, are subject to periodic debris flows and flooding. Depending on the climate and geology, the fans may recover quickly from the destructive effects of a debris flow event, offering little visual evidence of the active processes. In general, the existing channel on a debris fan cannot accommodate the next large debris flow. It cannot be assumed to be the only hazardous location on a debris fan. The landform is built up over the years as debris flows periodically deposit materials across the entire debris fan or portions of it. During a large flow a new channel may result from plugging of the existing channel with debris. Usually, the destructive forces of the debris flow decrease as one moves from the narrow, steep apex of the fan to the broader, gentler slopes down gradient. Correspondingly, the size of the material deposited decreases as the debris flow moves across the fan. Debris fans often are vegetated with cottonwood or aspen trees, grasses and shrubs in a distinct contrast to adjacent plant growth. Some debris fans in the high mountains also are subject to avalanches.

Structures and improvements on the apex of the fan may be destroyed or badly damaged while improvements farther down on the fan may only experience water and mud damage. Erosion and deposition on an active fan by successive debris flows is to be expected.

The best form of mitigation is based upon an understanding of the natural processes of a debris fan and locating and constructing improvements accordingly. Given the condition of a developed debris fan, measures that can be taken to decrease the hazard include building massive earth structures on the uphill slide of houses or other improvements to divert the flow to one side or the other, planting a dense row of trees, erecting retaining walls, and channeling the stream. These measures should be considered only after a complete understanding of the process is obtained because in many instances they could be of little benefit and could even increase the hazard to other developed areas.

Erosion/Deposition

Erosion is the resuspension and breakdown of material that moves from one location to another through the force of consistent aggression by water, wind, waves, thawing and freezing and ice. Deposition is the placing of eroded material into a new location. All material that is eroded is later deposited in another location. RBC has favorable conditions to have extreme erosion and deposition impacts.

Erosion and deposition are occurring continually at varying rates over the earth's surface. Swiftly moving floodwaters cause rapid local erosion as water carries away earth materials. Deposition occurs where flood waters slow down, pool or lose energy in other ways and the materials settle out. Similarly, wind erosion can occur from exposed areas such as fields, tailings and desert areas when materials are picked up and deposited when wind force diminishes. The potential of erosion is directly related to the hardness and adhesive character of various materials. Hard granites erode very slowly while soft silts and sands erode very quickly. Wildfire that destroys vegetation holding land in place can result significantly increased rates of erosion from water and wind.

Erosion can result in minor inconveniences or total destruction. Severe erosion removes the earth from beneath bridges, roads and foundations of structures adjacent to streams. Erosion and deposition are key factors in direct and indirect natural hazard impacts. Deposition material often produces a death by many small cuts as accumulated materials block culverts, aggravate flooding, destroy crops by burying them, and reduce the capacity of water reservoirs. Severe erosion from man-made alterations of the land can catalyze serious impacts including contributing to debris flows, landslides and flooding.

Human activities greatly influence the rate and extent of erosion and deposition. Stripping the land of vegetation, altering natural drainages, and rearranging the earth through construction of highways, subdivision development, farmland preparation, and modification of drainage channels for water control projects are significant factors in increased erosion and deposition. All the geologic processes that make available more material for erosion and deposition tend to increase the rates of each process. This is particularly true for landslides, mud flows, debris flows, earthflows, rock falls, and physical and chemical weathering.

The processes of erosion and deposition cannot be stopped totally. They can be reduced and controlled by surface drainage management, revegetation of disturbed lands, controlling stream-carried eroded materials in sediment catchment basins, and riprapping of erosion-prone stream banks, especially adjacent to structures. Understanding these processes and taking preventative action can lead to development and land-use methods that minimize losses.

Landslides

Landslides are the downward and outward movement of a slopes composed of natural rock, soils artificial fills, or combinations thereof. Common names for landslide types include slump, rockslide, debris slide, lateral spreading, debris avalanche, earth flow, and soil creep.

Landslides move by falling, sliding, and flowing along surfaces marked by differences in soil or rock characteristics. A landslide is the result of a decrease in resisting forces that hold the earth mass in place and/or an increase in the driving forces that facilitate its movement. The rates of movement for landslides vary from tens of feet per second to fractions of inches per year. Landslides can occur as reactivated old slides or as new slides in areas not previously experiencing them. Areas of past or active landsliding can be recognized by their topographic and physical appearance. Areas susceptible to landslides but not previously active can frequently be identified by the similarity of geologic materials and conditions to areas of known landslide activity.

Landslides in the U.S. are estimated to cause more than $1 billion a year in property damage, according to the Transportation Research Board of the National Academy of Sciences. Railroads, highways, homes, and entire communities are lost to landslides that demolish and/or bury them. In Colorado the 19th century mining camp of Brownsville just west of Silver Plume is buried beneath a rain-triggered landslide that became a debris flow. It is now under Interstate 70. Landslides occur commonly throughout Colorado, and the annual damage is estimated to exceed three million dollars to buildings alone.

Landslides are one of the primary natural processes shaping the land. Human activities that frequently cause significant increases in landslide activity include:

- Excavation of a steep slope or the toe of an existing landslide, thus removing support of the upslope mass,
- Addition of material to the head (top) of a landslide which pushed the slide material downslope,
- Addition of moisture to the landslide mass, increasing the weight and decreasing the strength

The activities that tend to increase landslide potential include excavation for highways and houses, lawn watering or surface drainage diversions, and changes in water infiltration rates. Alteration of surface land use such as road cuts and water impoundments, which allows more water into the subsurface of a slide-prone slope, is a major contributing factor in landslides.

Many methods of mitigation can be designed for active or potentially active landslide areas. These generally fall into four categories: 1) change of slope shape, 2) drainage management, 3) retaining structures, and 4) special treatments. Change of slope shape methods include excavating the entire slide, benching, excavating the upper part of the slide increasing the weight and resistance to movement of the lower part of the slide (loading), and a combination of excavation and loading.

Land Use

The above mitigation techniques can be quite costly, particularly for large landslide areas, and are often used only as a last resort or to protect expensive structures. Even then they may be temporary and in the long run ineffective. In general, recognition and avoidance of landslide areas with all structural land uses is desirable. Significant earth moving or structural use of the land nearly always justifies a thorough analysis of the landslide potential prior to construction, landslide-prone areas are unavoidable and mitigation measures must be utilized to fit the circumstances.

A school in Eagle County was proposed for the toe of on old landslide. A geologic examination revealed natural hazards and the location of the multi-story school, football field and grandstand area was moved to a safe site. The estimated savings: $3.5 million.

Rockfall

Rockfall is the falling of a newly detached rock from a cliff or steep slope. Rocks individually or as a rockfall can be of any dimension. Rockfalls (mass of moving rocks) are the fastest type of landslide and occur most frequently in mountains or other steep areas during early spring when there is abundant moisture and repeated freezing and thawing. The rocks may freefall or carom down in an erratic sequence of tumbling, rolling and sliding. When a large number of rocks plummet downward at high velocity, it is called a rock avalanche. Rockfalls are caused by the loss of support from underneath or detachment from a larger rock mass. Ice wedging, root growth, or ground shaking, as well as a loss of support through erosion or chemical weathering may start the fall. Single rock tumbles also result in impacts if the boulders are sufficient enough size. Some of the most spectacular events are when large individual rocks dislodge and careen into structures or onto roads.

Rockfalls can demolish structures and kill people. Rocks falling onto highways may strike vehicles, block traffic, cause accidents, and sometimes damage the roads. Minor but costly consequences are the work of clearing highways and borrow ditches in rockfall areas. Any structure in the path of a large rockfall is subject to damage or destruction.

Man's activities often cause rocks to fall sooner than they would naturally. Excavations into hill and mountainsides for highways and building frequently aggravate rockfalls. Vibration from passion trains or blasting can trigger them, as can changes in surface and ground water conditions. Rockfalls have been attributed to earthquakes and sonic booms.

The best way of dealing with rockfalls is to stay out of areas where rockfalls are naturally prevalent. If highways or other activities put people in rockfall areas, expensive methods can be utilized to decrease the likelihood and severity of rockfall damage. Some methods are removing unstable rocks, securing rocks to the slope so they will not fall and sheltering the improvements with earthen berms, fences, or other structural protection. In some instances of existing development, monitoring devices can be installed to warn approaching traffic of a rock fall. This measure could save lives, but will not protect property.

Swelling Soils or Rock

Swelling soils are soils or soft bedrock that increases in volume as they get wet and shrink as they dry out. They are also commonly known as bentonite, expansive, or montmorillinitic soils. Swelling soils contain a high percentage of certain kinds of clay particles that are capable of absorbing large quantities of water. Soil volume may expand 10 percent or more as the clay becomes wet. The powerful force of expansion is capable of exerting pressures of 20,000 psf or greater on foundations, slabs or other confining structures. Subsurface Colorado swelling soils tend to remain at a constant moisture content in their natural state and are usually relatively dry at the outset of disturbance for construction on them. Exposure to natural or man-caused water sources during or after development results in swelling. In many instances the soils do not regain their original dryness after construction, but remain somewhat moist and expanded due to the changed environment.

Swelling soils are one of the nation's most prevalent causes of damage to buildings and construction. Annual losses are estimated in the range of $2 billion. The losses include severe structural damage, cracked driveways, sidewalks and basement floors, heaving of roads and highway structures, condemnation of buildings, and disruption of pipelines and sewer lines. The destructive forces may be upward, horizontal, or both.

Design and construction of structures while unaware of the existence and behavior of swelling soils can worsen a readily manageable situation. Where swelling soils are not recognized, improper building or structure design, faulty construction, inappropriate landscaping and long term maintenance practices unsuited to the specific soil conditions can become a continuing, costly problem. Design problems might include improper foundation loading, improper depth or diameter of drilled pier, insufficient reinforcing steel, and insufficient attention to surface and underground water. Miscalculating the severity of the problem for a particular clay soil can result in damage although some mitigating measures were taken. Construction problems related to swelling soils include lack of reinforcing steel, insufficient or improperly placed reinforcing steel, mushroom-topped drilled piers, and inadequate void space between soils and grade beams. Allowing clays to dry excessively before pouring concrete and permitting the ponding of water near a foundation during and after construction also are contributing factors in swelling-soil related construction problems. Building without allowance for basement or ground floor movement in known swelling soils areas is a very common source of property damage. Improper landscaping problems include inadequate management of surface drainage and planting vegetation next to the foundation so irrigation water enters the soil.

Collapsing Soils

Collapsing and settling soils are relatively low density materials that shrink in volume when they become wet, and/or are subjected to great weight such as from a building or road fill. The process of collapse with the addition of water is also known as hydrocompaction. Collapsing and settling soils have considerable strength when dry and generally are not a problem to structures and improvements. When they become wet, they are subject to rapid collapse and can be reduced in volume as much as 10 to 15 percent. Surface ground displacement of several feet can result. Similar processes frequently affect old landfills or poorly placed earth fills.

Image at left. *Warped sidewalk due to collapsing soils near Meeker, Colorado. Photo by Jon White.*

The large ground displacements caused by collapsing soils can totally destroy roads and structures and alter surface drainage. Minor cracking and distress may result as the improvements respond to small adjustments in the ground beneath them.

Man's activities are definitely the cause of most soils collapsing. These activities include watering grass and shrubs, failing to repair leaking water lines in utility trenches, impounding water, blocking drainages by highways, loading excessive weight upon collapsible soils, and any activity which increases subsurface moisture in soils prone to collapse.

Man-made and/or man-placed materials frequently are subject to collapse and settlement. The filling of mined out areas, natural depressions and swamps with trash and debris is a common practice. Eventually the site is put to another use. Decomposition and compaction at landfill dumps also can result in generation of explosive methane and poisonous hydrogen sulfide gases, as well as pollution of subsurface water with carbolic acid or other chemicals. These problems, in addition to settling, occur despite compaction during the landfill operation.

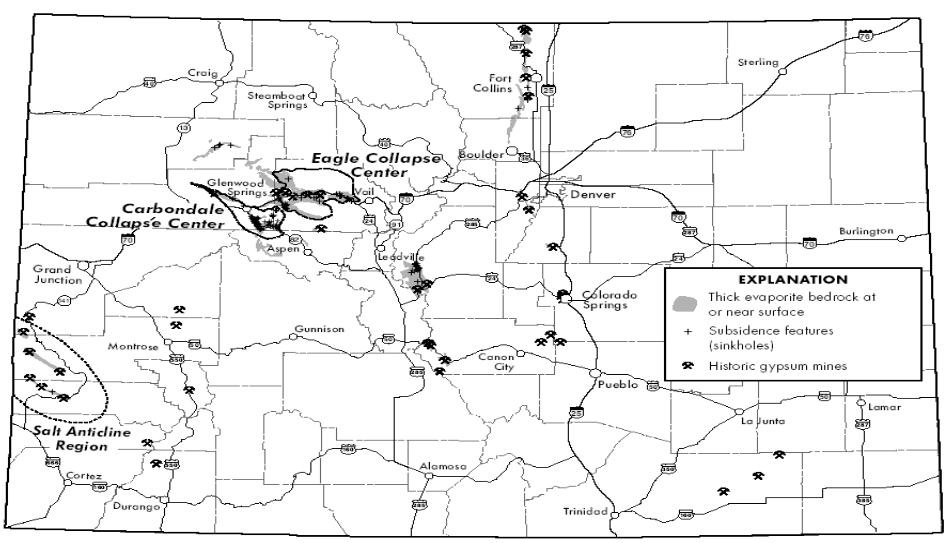
Damage to structures erected on landfills is common if proper construction methods are not used to counteract settling and other problems. Dangerous methane can seep into basements and crawl spaces and explode, demolishing the structure.

Images above. *Earth flow near Meeker, Colorado, July 22, 1996. In a matter of 5 hours, 1.5 acres of pasture was destroyed.*

Sinkholes

Most late Paleozoic and Mesozoic rock formations contain evaporite beds in Colorado. Some are thin and discontinuous—only minor beds within a rock formation. Others are massive, with evaporitic minerals many hundreds of feet thick. Millions of years of burial, plastic deformation, mountain building, and erosion have forced the evaporate beds to the shallow subsurface and/or ground surface today.

Evaporite minerals in Colorado are a valuable mining resource. Historic mining occurred throughout the state where thin gypsum beds were exposed. Active mining continues in the massive deposits near the town of Gypsum. Two characteristics of evaporite bedrock are important. One is that evaporite minerals can flow, like a hot plastic, when certain pressures and temperatures are exceeded. The second, and most important to land use and development, is that evaporate minerals dissolve in the presence of freshwater. It is this dissolution of the rock that creates caverns, open fissures, breccia pipes, subsidence sags and depressions, and sinkholes. These landforms are described collectively as karst morphology. Karst morphology originally referred to limestone areas known for characteristic closed depressions, sinkholes, caverns, and subterranean drainage. Evaporite karst comprises similar morphology where these features develop as a result of dissolution of the evaporite minerals. Exciting scientific work is ongoing in areas of evaporite karst in Colorado. The evaporite terrains of the Roaring Fork and Eagle River areas are centered in areas of Neogene deformation and regional subsidence, related to flowage and dissolution of evaporate minerals. Precise geologic mapping, river and hot springs water chemistry, and inconsistencies in superposition (elevations) of various volcanic flows compared to their determined ages has brought about new theories, and definable and defensible limits to the area of regional collapse. Highly contorted strata, collapse debris, structural sags, deformation of river terrace gravel, piercement structures, and river-centered anticlines are all geomorphic evidence of the subsidence and deformation. While regional collapse related to evaporite flowage and dissolution is fascinating to geoscientists, it is the associated risk from localized and potentially spontaneous subsidence that can be destructive to facilities and potentially life threatening. Secondary considerations include seepage susceptibility and potential failure of reservoir dams, and water-quality concerns with dissolved-salt loading of rivers. Most catalogued sinkholes of Colorado lie on surficial deposits such as flat-lying glacial outwash terraces, recent valleyside sediments, or older deposits on pediment slopes overlying the evaporite bedrock. Some sinkholes, fissures, and caverns are exposed in the actual bedrock.



Evaporitic bedrock locations in Colorado—GYPSUM MINES FROM MINERAL RESOURCES OF COLORADO, 1968, P. 191; GEOLOGY MODIFIED FROM TWETO, 1979

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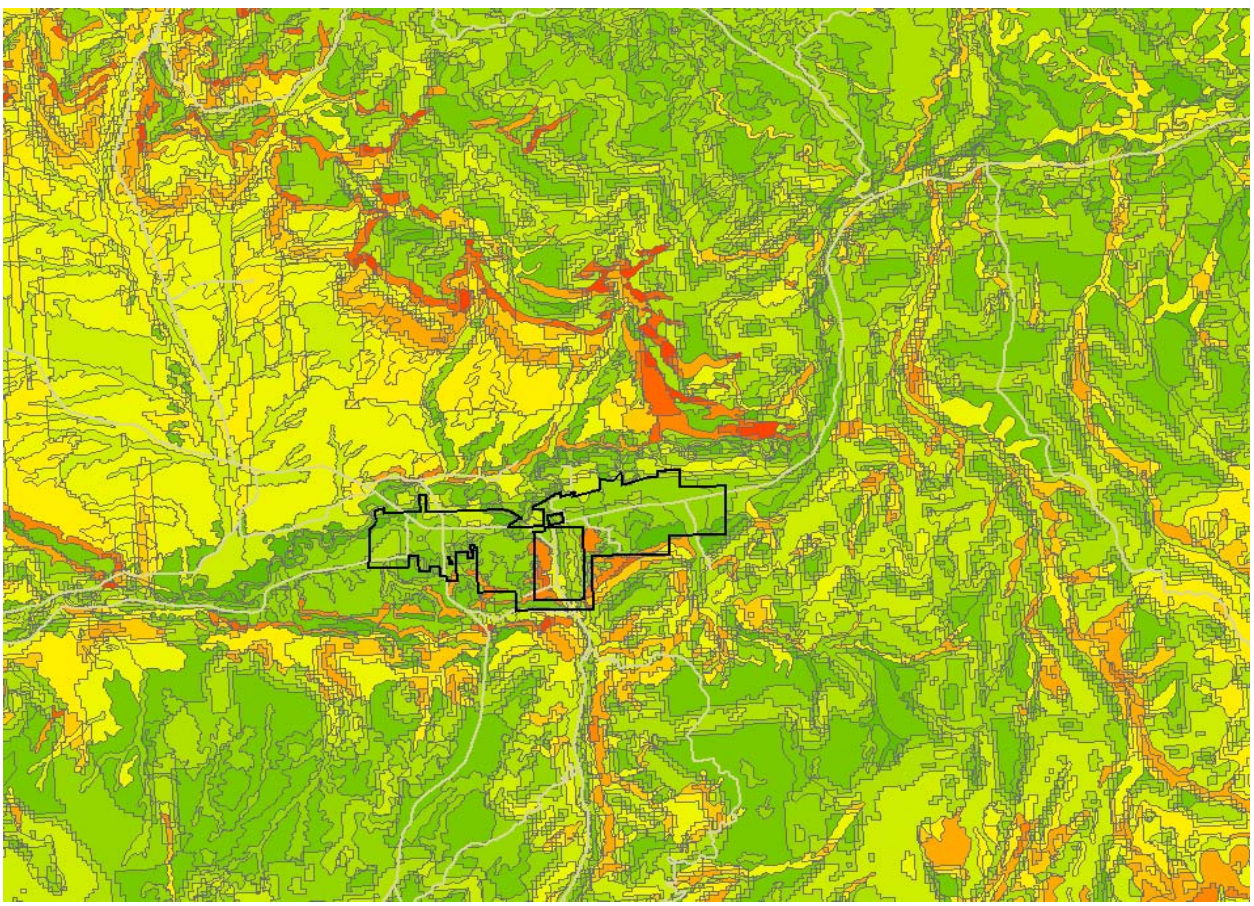
The highest densities of sinkholes that are manifested at the surface in Colorado occur in the Roaring Fork River-Carbondale area in Garfield County, the Eagle River around Gypsum and Edwards in Eagle County, the Buford-North Fork White River area in Rio Blanco County, and Park County south of Fairplay (see map on page 6). Where evaporite bedrock is exposed at the surface or under-lies thin surficial soils there is some risk that subsidence could occur. The associated risk rises where the frequency of sinkholes increases. Dangerous and life-threatening spontaneous collapse and opening of subsurface voids are rare, but do occur. More commonly, differential strains and settlement from localized ground subsidence or piping (removal of fine soils into subsurface voids) will damage facilities that are unknowingly constructed over a sinkhole or subsidence trough. Where subsidence features are exposed at the surface and properly identified, they should be avoided if possible. Many older sinkholes have been covered with recent soil infilling and are completely concealed at the surface. While some concealed sink hole locations can be seen in aerial photography by vegetation changes, only subsurface inspections, either by investigative trenching, a series of investigative borings, geophysical means, and/or observations made during over lot grading or utility installation, would ascertain whether sinkholes exist within a development area. If such hidden sinkholes are located, an experienced geotechnical firm should be retained to evaluate the hazard and potential for future subsidence on the development. There are both ground-modification and structural solutions that can help mitigate the threat of subsidence if avoidance is not an option. Drainage issues and proper water management are as important as they are for collapsible soils. Additional increases of fresh water may accelerate dissolution, destabilize certain subsidence areas, re-open or establish new soil pipes to bedrock voids, and rejuvenate older sinkholes.

Several sinkholes give the name to Pothole Valley, east of Buford on the North Fork of the White River

Mitigation and Methodology for Determining Risk for Geologic Stability Hazards

Understanding the stability of geological structures is a complex task that is dependent on a number of factors. These factors include adhesion, hardness, plasticity, fragment size, permeability, mineral type, organic matter and a host of lesser and more complex characteristics. Many of the most important characteristics and factors have been described and mapped in reasonable detail through the National Cooperative Soil Survey a which is a joint effort of the USDA, NRCS, BLM and BOI with cooperation and input from a variety of sources. The basis for modeling the key characteristic s of natural hazards based on land stability is the Soil Survey of Rio Blanco County Area issued in 1982. Parameters in the model are slope, shrink/swell potential, and erosion in a dataset created by intersect of slope with soils. Landslide hazard is determined as slope+swell+erosion. Erosion is determined from weighted erosion factors. Weighting of the parameters is as follows:

Slope		Swell/Shrink		Erosion		
	Weight		Weight	K Code	Descriptor	Weight
0-3%	1	Low	1	.05-.21	Low	1
3-8%	2	Moderate	2	.21-.37	Moderate	2
8-15%	3	High	3	.37-.53	High	4
15-33%	4	Very High	4	.53-.69	Very High	6
33-50%	5					
50%+	6					



Example of hazard map for landslides used in this plan to identify mitigation priorities: Rangely Area

Part V

Mitigation

Determining Priorities

Once data on hazard and vulnerability is generated it has to be analyzed and refined to reveal not only where risk exists but the type, extent, and character of the risk. Data generation does not create information. Information is the result of analysis of data. Risk is a type of information that indicates potential danger. From risk information a series of questions can be asked about how the danger can be reduced and/or eliminated. It is this risk information that decision-makers use to establish priorities and allocate resources to mitigate hazards. The actions implemented as a result are part of a risk management approach.

The following information outlines sets of proposed projects for mitigating risks described in this plan for the various types of hazards identified. Using a consensus based planning approach, as described in Section I and II of Part III of this document, priority projects for mitigating risks from hazards have been determined. In order to represent the variable nature and differing levels of planning required to organize mitigation activities the following generic format has been used. The legend for the project tables used to categorize information on proposed mitigation activities is as follows.

Name, Number, and Hazards Addressed: The name, RBC mitigation activity number (RBCM#) and types of hazards addressed such as wildfire, flood, erosion, debris flow, etc.
Type: The generic classification for the type(s) of activity.

- Constructing (Includes activity such as fuel reduction)
- Studying
- Engineering
- Planning
- Facilitating
- Financing

Purpose: The generic reason for the type of activity. A partial list includes:

- Creating information/maps
- Designing project features
- Analyzing situations/NEPA
- Regulatory compliance
- Consensus building
- Defining options and approaches
- Understanding dynamics and options
- Seeking funding
- Building and/or accomplishing mitigation features and activities

Scale: Extent of area and or complexity for the activity.

- Broad (1/4 of RBC and/or ecologically/very complex)
- Standard (Confined to a given area/sub-basin and/or moderately complex)
- Narrow (Site specific and/or complexity is resolution of engineering problem)

Span: Defining the time scale for the activity-short-term, mid-term, long-term.
Description: Narrative on the character of the problem.
Resources: Provides a basic outline of stakeholders.
Cost/Benefit: Outlines resources at risk, cost if situation is not addressed, provides analysis of benefit cost however further FEMA BCA data and/or actions required to meet BCA guidelines will be required to justify funding in the future.
Mitigation: Project expectations and/or assumptions about possible mitigation approaches.

This information has been formatted in the following manner to describe each specific activity of proposed mitigation.

Name/Number/Hazard(s): RBCM#
Type:
Purpose:
Scale:
Span:
Description:
Resources:
Cost/Benefit:
Mitigation:

Potential Mitigation Activities

Analysis of the risk information generated for hazards in RBC has revealed that of all the hazard types wildfire has the potential to create the most severe impact. A more severe event could occur if Kenney reservoir was to fail however this event is of low probability and is not directly or foresee ably attributable to a natural hazard. Wildfire is a consistent natural hazard with a high probability of impact. Based on analysis of the natural hazards within the county the events of concern are as follows:

- Wildfire
- Flash flood
- Debris flows
- Ice Jam
- Collapsing Soils
- Spring Flows
- Erosion/Deposition
- Avalanche
- Sinkholes
- Landslides
- Rockfall
- Swelling Soils
- Extreme Cold/Snow

Potential mitigation projects are listed in the following section. These are listed as projects and do not represent an order of preference or importance. The local priority list outlines the projects picked in order of priority for the community and is the succeeding section.

Name/Number/Hazard: Flash Flooding and Highly Erosive Lands Dynamics Study for Western RBC. RBCM#-001: Flash Flood, Debris flows, Erosion/Deposition, Collapsing Soils
Type: Study
Purpose: Understanding dynamic of the situation and options for mitigation
Scale: Broad
Span: Short
Description: Flash flooding, debris flows, and the associated impact from erosion have and are continuing to cause impact in most drainages in central and western RBC. The problems that result from flash flooding are destruction of infrastructure (roadways, bridges), diminishment of agricultural productivity, damage to industrial operations (oil and gas), and ecological loss. The impact has been distributed across all infrastructure types such that both high volume major arterials and low volume county roads have been impacted. Problems include stream stability, erosion, and engineering of water passage. Noticeably inadequate engineering of water passage for dry arroyos is a major cause of infrastructure damage. This includes State as well as County, and local BLM, and Forest roads used for oil and gas operations, and other multiple uses including ranching and recreation.
Resources: Cooperation-RBC, BLM, Rio Blanco Water Conservancy District (RBWCD), NRCS.
Cost/Benefit: Information resulting from this project should result in high benefit over cost relationships. The impacts include dams, roads, and bridges. Some projected ratios show a benefit of forty dollars saved for each dollar spent.
Mitigation: Develop a research project with the specific goal of defining the nature of flash flooding and its associated impacts in western RBC. Use this as a basis for environmental assessments for mitigation projects and mapping hazard areas. The study should include of the rate and impact of erosion, reconnaissance mapping, and impacted and/or potentially impacted features of value such as infrastructure. In areas identified as prioritized from reconnaissance as unstable, restoration plans should be developed and implemented. Additionally new floodplain mapping should be developed and the situation monitored as information is generated and/or conditions change. A full accounting system (GIS special database with responsibility and funding outlined) for tracking infrastructure impact from flash-flooding for roadways, bridges and property should be developed. This database should be used to track priorities for mitigation.

Name/Number/Hazard: Upper Kenney Floodplain Shifting Analysis. RBCM#-002: Ersion/Deposition
Type: Study
Purpose: Creating information and updating maps
Scale: Narrow
Span: Short
Description: Erosion of sediment into Kenny reservoir has changed the floodway. The reservoir is being filled rapidly and studies of this phenomenon have been done, however the floodway above the sedimentation section at the mouth of the reservoir changes yearly as it continues to receive material. The floodplain map, because of these changes is not representative of the situation and potential high water could have a profound impact on infrastructure and property.
Resources: County and RBWCD project management of contractor.
Cost/Benefit: Potential high as development above reservoir is possible however it is not imminent.
Mitigation: A study should be carried out to determine the extent of erosion of sediment into Kenny reservoir and the impact to the floodway. While studies of this phenomenon have been done, new information is needed for the floodway above the sedimentation section at the mouth of the reservoir. The floodplain map should be updated based on the findings of the studies. Project plans should be developed, if required, to mitigate potential hazard.

Name/Number/Hazard: Arresting Flash flood and Erosion through Riparian and Creek Restoration Projects. RBCM#-003: Flash Flood, Debris flows, Erosion/Deposition, Collapsing Soils
Type: Planning and Construction
Purpose: Plan specific activities, ensure they are in compliance with applicable regulations, and construct mitigation features.
Scale: Broad
Span: Long
Description: Every time a flash flood event occurs the highly erosive soils mobilized put increasing loads of sediment into Kenney reservoir. Creek restoration to reduce flash flood impact is a priority identified by the RBWCD in order to slow the sediment rate into Kenney Reservoir. While the extent of floodplain distortion needs to be determined, these erosion control projects need to move forward. The District, in cooperation with BLM, is working on small stabilization projects. Detailed planning for stabilization and NEPA compliance for the entire project is needed. Additionally funds for on the ground activities permitted now is required.
Resources: Cooperative effort between RBC, BLM, RBWCD.
Cost/Benefit: Estimated to be in the order of for every dollar spent forty will be saved.
Mitigation: Funds, planning, environmental analysis for further projects, and construction of identified sites that are permitted for creek restoration in areas of flash flood and associated erosion (as identified by the RBWCD) to slow the sediment rate, are needed now. These erosion control projects need to move forward to slow further destructive processes. The District, in cooperation with BLM, is working on small stabilization projects.

Name/Number/Hazard: RBC Community Based Consensus and Solutions for Watershed Sustainability. RBCM#-004: All Hazards except Avalanche
Type: Planning
Purpose: Organize and plan
Scale: Broad
Span: Long
Description: A comprehensive approach to integrated water related issues is not in place. Defined actions for resolving issues that are common to flood, but not commonly considered by the agencies or stakeholders, are not addressed. These considerations include flood related issues that are not considered in NEPA analysis done for activities on BLM lands when permitting oil and gas operations, stability of floodways is not managed or considered before construction of non-traditional projects such as irrigation and roadways, and stability is not a priority of land managers whether private or public. This is impacting water quality, deteriorating or causing the loss of productive land and shifting floodways and plains way beyond the area of actual action (sedimentation). Combined these activities are resulting in more devastating flood events.
Resources: All involved parties RBC, federal, state, local and private
Cost/Benefit: The cost of not communicating and reacting to problems is higher than working together and resolving issues.
Mitigation: A watershed group, following comprehensive systems management approach, that includes flood related issues, should be created. A possible activity to be discussed in the near future is to have the stakeholder council for this plan develop into a watershed council. This group would then develop a program charter with statement defining mission, objective, resources and action plans for this concept.

Name/Number/Hazard: Updating Information Bases for Decision-makers. RBCM#-005: Flash Flood, Spring Flows
Type: Study and Planning
Purpose: To ensure that accurate data is available and used throughout the county and in both towns.
Scale: Broad
Span: Long
Description: Floodplain maps are not representative of conditions on the ground. Tributaries to the White River in RBC are representative of large alluvial deposits that at some time in the near past were healthy riparian areas. Because of riparian destruction and erosion of the alluvial deposits, the creek bottoms and thereby the floodways and related plains are no longer represented well (if at all) on the maps. In some cases erosion has caused a canyon like affect that has widened and deepened the drainages by hundreds of feet. A lack of good up to date and digitally organized information hinders good decision making. RBC is committed to use and implementation, for use in making decisions, of the HAZUS model.
Resources: RBC, CWCB and FEMA
Cost/Benefit: Without accurate data bad decisions that lead to costly mistakes can be made.
Mitigation: Floodplain maps need to be referenced, digitalized to vector or other overlay capacity and approved for use as a layer in geographic information system (GIS).

Name/Number/Hazard: Understanding the Dynamic of kenney reservoir. RBCM#-006: Spring Flows, Ice Jams
Type: Study
Purpose: Understand situation
Scale: Narrow
Span: Short
Description: Determine whether the creation of Kenney reservoir has had an impact on the flooding in Rangely. Of particular interest is the impact to the floodplain and associated maps. Historical data indicates that ice jams have been a threat in the Rangely area and they are no longer a prevalent phenomena.
Resources: RBC, Town of Rangely, CWCB and FEMA
Cost/Benefit: Verify the status of present assumptions so cost can be considered.
Mitigation: Develop a study to determine what the flood situation really is in Rangely, verify for accuracy and adjust decision-making to reflect this information.

Name/Number/Hazard: Responding to Ice jam threats. RBCM#-007: Ice Jams, Extreme Cold
Type: Plan
Purpose: Ensure that response considerations are organized.
Scale: Narrow
Span: Short
Description: The ice jam situation around Meeker is not completely understood and mitigation is being considered. A response plan organized and reflecting the measures planned by all stakeholders should be added to the RBC Emergency Management Plan.
Resources: Specifically the emergency services in and around Meeker, RBC and the Town of Meeker.
Cost/Benefit: The organization is easier than the cost of learning during the event.
Mitigation: Defining a descriptive procedure for preparedness and response activities for ice-jamming incidents should be developed.

Name/Number/Hazard: Disappearing CR-7 Improvement project RBCM#007: Collapsing Soils, Ersion/deposition
Type: Engineering and Construction
Purpose: Designing and building mitigation projects
Scale: Narrow
Span: Short
Description: Severe erosion, because of frequent flash-flooding and inherently unstable soils, is threatening and/or causing loss of roadway on County Road 7. An engineering analysis, project plan, funding, and construction to correct this problem is needed.
Resources: RBC
Cost/Benefit: Entire reconstruction of these paved sections is a more expensive than mitigation. Mitigation prevents loss resulting from the eventual impact in terms of protection public safety and disruption of service. Mitigation ratios are expected to be several dollars saved for each dollar spent.
Mitigation: A project plan for County Road 7 on identified problem spots should be created. A long-term fix (the County has provided short-term stability) needs to be developed. The project plan should include engineering options, decision support process, budget and schedule. Funding should be sought to complete this activity within two years.

Name/Number/Hazard: mitigation of Ice Jams Around meeker. RBCM#-008: Ice jams, Extreme Cold
Type: Planning and Design
Purpose: Plan and design mitigation features
Scale: Narrow
Span: Standard
Description: Ice jamming in the White River next to Meeker, in an area that transects both the City and County, has threatened structures and infrastructure periodically. The occurrence interval is irregular however it appears to be based on particular weather phenomena consistent in the region. Structural and non-structural mitigation could be used to mitigate the hazard. No analysis has been done to establish the extent of hazard at a 1% probability of occurrence.
Resources: RBC, Town of Meeker, CWCB.
Cost/Benefit: The frequency curve on this event appears to represent a 10% probability of occurrence (one per ten years) for a threatening and/or loss event. Residential structures, infrastructure, community disruption, and potentially developable land are part of the impact. Possible mitigation has a potential ratio for every dollar spent two will be saved.
Mitigation: Based on study information a comprehensive plan that flood proofs the community and future development should be developed. Considerations in the plan should include protect present uses, enhances the river corridor and wherever possible provide community amenities to mitigate ice jamming in and around Meeker. The plan should outline alternatives that could be used to mitigate the hazard. The plan should be based on information from study that indicates the extent of potential issue at a 1% probability of occurrence. Mitigation activities for ice-jamming incidents can then be developed. Activities resulting from the plan would be implemented over several years.

Name/Number/Hazard: Water Passage Structures on CR-5. RBCM#009: Flash Flood, Debris flows, Erosion/Deposition
Type: Funding and Engineering
Purpose: Designing water passage projects
Scale: Narrow
Span: Short
Description: Water (flash flood passage) was not adequately designed into crossings for RBC road 5. This paved, highly important access to oil, gas and nahlcolite operations has evolved from an Indian track to a major highway. The result of this evolution has resulted in a patchwork of engineered road segments. For some of these segments water passage structures need to be upgraded. RBC is undertaking redevelopment of the entire road. Funding for this activity has been allocated and some grants received.
Resources: RBC, State of Colorado
Cost/Benefit: Correctly designed water passage is a necessary requirement to prevent reconstruction.
Mitigation: Additional funding is needed. This project consists of seeking funding for engineering to design water passage structures as part of the overall reconstruction process of CR-5. Once flood relevant funding is received it will be used to specifically design water passage structures.

Name/Number/Hazard: Repairing Stability in Highly Erosive Creeks RBCM#010: Erosion/deposition
Type: Funding and Restoration
Purpose: Eradicating invasive plant species
Scale: Broad
Span: Long
Description: The impact of flash flooding events has been made worse as the natural vegetative community has been replaced by tamarisk (also called salt cedar). The mono-cultural aspect of tamarisk promotes creek instability that is otherwise provided by the more diverse natural vegetation and seriously affects water availability and quality. RBC is in the position to arrest this problem. Mapping indicates that the basin could be made free of tamarisk and creek stability could be improved.
Resources: RBC, BLM, private landowners
Cost/Benefit: The linkage between loss of habitat and creek instability, resulting in more devastating flash flooding is clear. The broad impacts will intensify as the multiple factors involved in creek instability accelerate.
Mitigation: Funding is needed for the weed department of the RBC to start at eradicating tamarisk at key upstream points in the basin.

Name/Number/Hazard: Eastern Rio Blanco County Electrical Infrastructure Wildland Fire Mitigation Project RBCM# 011: Wildfire
Type: Planning, Financing, Constructing
Purpose: Building and/or accomplishing mitigation features and activities
Scale: Broad
Span: Long-term
Description: The purpose of this project is to mitigate wildfire hazards for key electrical lines that service mining, and oil and gas facilities. In mitigating these wildfire hazards consideration has been given to the need to balance various competing values involving cost, environment, practicality and capacity. Wholesale clear-cutting has been rejected as not prudent for both environmental and cost considerations. The objective of this project is development of a fire resistant landscape that accommodates electrical infrastructure and that can be maintained with minimal cost and environmental disturbance, and result in a less intrusive and safer solution than suppression as an act of control.
Resources: BLM, USFS, RBC, WREA
Cost/Benefit: Simple cost benefit analysis, used as part of the exposure assessment for priority setting, has indicated \$8 can be saved for each \$1 spent on mitigation of electrical lines without consideration of the cost of impact because of industrial disruption. When industrial (mining, oil, gas) disruption is included the ratio shifts to several hundred to one. In one case it has been estimated that an entire operation may have to cease (go out of business) if electrical service is disrupted.
Mitigation: This is a multi phase project that requires plans within plans, funding, and a lot of on the ground hand removal of fuels.

Name/Number/Hazard: Preplanning Avalanche Response RBCM# 012: Avalanche
Type: Facilitating Public Understanding of Hazard of Avalanche in RBC Backcountry
Purpose: Public Education
Scale: Broad
Span: Long-term
Description: **Mitigation Procedures** The location, time, and magnitude of avalanche events are difficult to predict. Potentially destructive avalanches are relatively common in the Colorado mountains. Use of public and open space lands will continue. RBC has to have a vigilant program of notification of the hazard of avalanches and rescue as a contingency in the event of entrapment of person by avalanche.
Resources: USFS, RBC
Cost/Benefit: Minimal cost for preplanning.
Mitigation: Establish a program of backcountry notification and mapping of avalanche potential. Distribute this information and make available to backcountry users. Have this information available for dispatch and pre-scout and preplan rescue in these zones.

Name/Number/Hazard: North Meeker Trail Wildfire Mitigation Project RBCM# 013: Wildfire, erosion/deposition
Type: Planning with potential Financing and Constructing
Purpose: Fuels Mitigation and Suppression Access with Community Enhancement
Scale: Narrow
Span: Mid-term
Description: Analysis has identified a wildfire hazard in the north Meeker area that is a potential a threat to life and property. The problem will increase as designated building sites are developed. Involved with this threat is the specter of landslides if the slope is destabilized after a fire. Soils in Rio Blanco County are notorious for their instability, particularly after the monsoons thunderstorms that commonly follow the traditional wildfire season. This area is also a patchwork of private and public land. Utility easements and fire breaks have become recreational access and areas of private and public land are used by town residents for a diverse range of activities that include hiking, biking, four wheeling and children playing. These uses and potential growth in the area will eventually lead to emergency response scenarios that will become compounded if the areas hazards are not realistically addressed. Additionally, issues of trespass, privacy and landowner impact are growing. While a considerable amount of mitigation is directed at Bureau of Land Management public land, some mitigation on private and easements should be encouraged and accomplished where possible.
Resources: BLM, RBC
Cost/Benefit: Advanced mitigation and full implementation of the mutually compatible alternative represents a 4 to1 cost benefit ratio. Potential loss of structures is 4 to 7 as of 2003. Build out could reach 10 or more. If all these structures and utility features are destroyed a loss of over $1.5 million could be realized. Project estimates are $250 to 500 thousand range for the mutually compatible alternative.
Mitigation: One potential option is to take no action to mitigate or provide public use. This would maintain the present situation. This alternative does not rectify the fire and post fire erosion issues and does not protect existing uses in the event of a fire including power transmission and homes. It also does not address the trespass and nuisance issues that increase community risk. These include rescue, fire, search and safety parameters. Fire Mitigation Alternative: A fire mitigation plan can be put into affect for the area. In this scenario no effort would be put into providing access to the public. This alternative provides fire mitigation but does not address other land related issues including long-term maintenance of the area to provide protection. The development of mitigation tactics that could be enhanced by clustering them with other structural development such as access, fire breaks and long-term maintenance is not addressed. Resolving trespass and liability issues would not be attempted. Mutually Compatible Alternative: The goal of this alternative is to combine the expenditure of wildfire mitigation with the development of a community recreational asset to resolve a host of issues. It is the proverbial "win/win" concept. The list of issues requiring resolution is long and includes trespass, nuisance, fire access and property development, among others. Whatever is attempted should consider how to provide the best situation for homeowners, public land users, first responders and the community as a whole. Design is the key to this alternative. The design must combine the various elements to find the best way to accomplish the goals of all those involved. While this alternative will provide the best level of mitigation, it also has a moderately higher cost as it also resolves issues that are not addressed in the other alternatives.

Name/Number/Hazard: RBCM#014 Extreme Cold and Snow Prepardedness
Type: Planning
Purpose: Public education
Scale: Broad
Span: Long-term
Description: **Plan Ahead** Put together an extremely cold weather every winter preparation public education campaign
Resources: RBC, USFS, BLM
Cost/Benefit: Low cost
Mitigation: Public education program

Name/Number/Hazard: RBCM#015 Drought Preparedness
Type: Preplanning
Purpose: Prevent level of impact
Scale: Broad
Span: Long-term
Description: Summer time activity, whether on the playing field or the construction site, must be balanced with measures that aid the body's cooling mechanisms and prevent heat-related illness. Air-conditioning is the number one protective factor against heat-related illness and death. If a home is not air-conditioned, people can reduce their risk for heat-related illness by spending time in public facilities that are air-conditioned. Suggestions for preventing a heat-related illness include frequently drinking water or nonalcoholic fluids; wearing lightweight, light-colored, loose-fitting clothing; and reducing or eliminating strenuous activities or doing them during cooler parts of the day. Periodically checking on neighbors who do not have air conditioning is recommended. By knowing who is at risk and what prevention measures to take, heat-related illness and death can be prevented.
Resources: RBC, NRCS, State of Colorado, USFS, BLM
Cost/Benefit: Low cost
Mitigation: Public education and partnership planning and development to help bring parties together.

Name/Number/Hazard: RBCM#016 Wolf Creek Reservoir, Drought, erosion/deposition
Type: Great works project
Purpose: Prevent/reduce impact of regional and statewide drought and sediment control for Kenney reservoir
Scale: Standard
Span: Long-term
Description: Build the wolf creek reservoir.
Resources: Local, State and Federal.
Cost/Benefit: To be worked out in engineering feasibility
Mitigation: Build the dam.

Priority List and Action Plan

RBC Mitigation Project Number	Name of the Project	Hazard	Priority Number	Level of Urgency	BCA
RBCM#-001	Flash Flooding and Highly Erosive Lands Dynamics Study for Western RBC.	Flash Flood, Debris flows, Erosion/Deposition, Collapsing Soils	**10**	**2**	**1+**
RBCM#-002	Upper Kenney Floodplain Shifting Analysis.	Erosion/Deposition	**12**	**2**	**1+**
RBCM#-003	Arresting Flash flood and Erosion through Riparian and Creek Restoration Projects.	Flash Flood, Debris flows, Erosion/Deposition, Collapsing Soils	**2**	**3**	**3+**
RBCM#-004	RBC Community Based Consensus and Solutions for Watershed Sustainability.	All Hazards except Avalanche	**5**	**2**	**1+**
RBCM#-005	Updating Information Bases for Decision-makers.	Flash Flood, Spring Flows	**14**	**2**	**1+**
RBCM#-006	Understanding the Dynamic of Kenney reservoir	Spring Flows, Ice Jams	**13**	**2**	**1+**
RBCM#-007	Responding to Ice jam threats.	Ice Jams, Extreme Cold	**15**	**3**	**1**
RBCM#-008	Mitigation of Ice Jams Around Meeker	Ice jams, Extreme Cold	**16**	**1**	**1**
RBCM#009	Water Passage Structures on CR-5	Flash Flood, Debris flows, Erosion/Deposition	**3**	**2**	**2+**
RBCM#010	Repairing Stability in Highly Erosive Creeks	Erosion/Deposition	**11**	**2**	**1+**
RBCM# 011	Eastern Rio Blanco County Electrical Infrastructure Wildland Fire Mitigation Project	Wildfire	**1**	**3**	**10+**
RBCM# 012	Preplanning Avalanche Response	Avalanche	**6**	**2**	**1+**
RBCM# 013	North Meeker Trail Wildfire Mitigation Project	Wildfire, erosion/deposition	**4**	**2**	**2+**
RBCM#014	Extreme Cold and Snow Prepardedness	Extreme Cold and Snow	**8**	**2**	**1**
RBCM#015	Drought Preparedness	Drought	**7**	**2**	**2+**
RBCM#016	Wolf Creek Reservoir,	Drought, erosion/deposition	**9**	**1**	**2+**

BCA estimates need to be further refined (greater than 1 indicates a benefit over a cost)
Level of Urgency: 3 = ASAP, 2 = within several years, 1 = need to be completed yet has long-term horizon.

Revisions and Future Planning

After this plan is adopted RBC will initiate planning to implement priorities. Detailed action plans with deeper descriptions, maps and project planning will be developed. As these plans are completed they will be come part of this program. These plans will be used to seek funding (when applicable) from various sources including FEMA, and private agencies and implement activities whenever possible. RBC will also seek to have these priorities reflected in local agency land management plans. At a minimum, on a yearly basis the emergency planning council will review the status of the program and make appropriate changes to reflect existing conditions. RBC will monitor progress and track flood impact in the county and use this information to ensure the program reflects current conditions.

Appendix

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